THE SILURIAN ROCKS OF THE LUDLOW DISTRICT, SHROPSHIRE

BY

CHARLES HEPWORTH HOLLAND, Ph.D.
(University of London, Bedford College)

JAMES DIXON LAWSON, Ph.D.
(University of Glasgow)

AND

VICTOR GORDON WALMSLEY, Ph.D.
(University College, Swansea)

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By C. H. HOLLAND, J. D. LAWSON,

AND

V. G. WALMSLEY

CONTENTS

SYNOPSIS

The Silurian rocks of the Ludlow district have been re-mapped. The strata are folded into an asymmetrical anticline plunging east-north-eastwards. Of the two formations of the Wenlockian Series, the Wenlock Shales are of the typical shelf development but the Wenlock Limestone is more argillaceous and less fossiliferous than on Wenlock Edge. The Ludlovian Series comprises nine stratigraphical divisions recognized by faunal and, to a lesser extent, lithological criteria. A standard section is described for each boundary. Significant changes in lithology and fauna take place at some levels towards the west of the area, as the basin facies is approached.

The base of the Ludlovian Series is described at a standard section and four stages (Eltonian, Bringewoodian, Leintwardinian and Whitcliffian) are introduced. The boundaries between them are defined at standard sections. The base of the Downtonian Stage, and hence that of the Lower Old Red Sandstone Series, is also formally fixed at the base of the Ludlow Bone Bed at " Ludford Lane ".

A correlation chart links the local Ludlovian successions in the Welsh Borderland and south-central Wales with this new classification for the type area.

I. INTRODUCTION

The Ludlow district is historically important as the type area selected by Murchison for the Ludlow Series of his Silurian System. In recent years, most of the Ludlovian

strata of the Welsh Borderland have been re-mapped, and it was as a result of difficulties experienced when correlation with the type area was attempted, that the necessity for a revision of this area became clear.

A brief summary of the new classification has already been published (Holland, Lawson & Walmsley, 1959). Full details are now presented and four Ludlovian stages are introduced. Standard sections on which they are based, selected from the type area, are described in detail. The correlation chart of Welsh Borderland Ludlovian (shelf and basin facies) summarizes the authors' views.

The continuity of the north-east to south-west regional strike of the south-easterly dipping Silurian rocks of the main outcrop is broken in the Ludlow district by an asymmetrical anticline plunging east-north-eastwards. It is this denuded Ludlow Anticline which provides the type area.

In the core of the anticline the Wenlock Shale outcrop forms ground between 400 ft. and 500 ft. O.D., partly covered by river alluvium. The succeeding Wenlock Limestone gives rise to a V-shaped wooded scarp (see Plate 1) about 800 to 900 ft. O.D. overlooking the Wenlock Shale plain. Between the Wenlock Limestone scarp and the higher scarp feature formed normally by Bringewood Beds, the softer Lower and Middle Elton Beds form either a ledge or a valley. The wooded ridges of Bringewood Beds rising to 1,192 ft. on Bringewood Chase, 1,235 ft. on High Vinnalls, and over 1,000 ft. on Mary Knoll, fall away to the north, east and south in gentle dip slopes of higher Ludlovian strata towards the mainly flat-lying Downtonian outcrops which bound the area.

The area has been mapped on the following Six-inches to One Mile Ordnance Survey Sheets: Shropshire 77 S.E., 78 N.W., 78 N.E., 78 S.E., 78 S.W., 82 N.E. It is covered by the Ordnance Survey 1 : 25,000 Sheets SO 47 and SO 57 and the One-inch Sheet 129. The district is included on the Geological Survey Old Series One-inch Sheet 55 N.W.

In descriptions of lithology, the Rock Color Chart (1951) of the Geological Society of America, the Wentworth 1922 scale of grade and class terms for clastic sediments, and the bedding terms defined by Holland (1959 : 451) have been used. Authors of Ludlovian fossil species are given in the List of Fossils (see p. 152).

Probably the earliest reference to the geology of the Ludlow district was by Wright (1832) who gave a general description of the "Secondary Formations" in this neighbourhood. Murchison (1833 : 475) established the descending sequence of, I. Upper Ludlow rock ("named because the Castle of Ludlow stands upon it"), II. Wenlock Limestone (in which he apparently included the limestones of both Wenlock Edge and Aymestrey) and III. Lower Ludlow Rock. He suggested "the term Ludlow Formation (the upper and lower Ludlow rock being subordinate members), as applicable to all the higher portion of this [Grauwacke] series which has a tripartite character in Salop and Hereford, due to the interpolation of the Wenlock and Aymestrey Limestone" (p. 477).

This initial confusion of the limestones was quickly resolved by Murchison (1834) who produced a "Table of the stratified Deposits beneath the Coal measures" covering much of the Welsh Borderland and South Wales, and giving the thickness, lithological characters, characteristic organic remains and main localities of each of

the formations. Part of this table shows :

Old Red Sandstone		c. Tilestone
Upper Grauwacke Series	I. Ludlow rocks	d. Upper Ludlow rock e. Aymestry and Sedgeley limestone f. Lower Ludlow rock
	II. Wenlock and Dudley rocks	g. Wenlock and Dudley limestone h. Wenlock and Dudley shale

Here the two limestones were recognized as being of different ages and the name " Aymestry ", with the second " e " omitted, was applied to the higher one.

Murchison (1835 : 46) made the first reference to the " Silurian System of Rocks ". The publication in 1839 of his " Silurian System " provided the first detailed account of these rocks and of the Ludlow district and figured the organic remains by which the subdivisions were to be recognized. No precise limits to the system were defined, but Murchison's references (pp. 181, 198) to the " Downton Castle building stone " as " constituting the upper stratum of the Silurian System, and the ' bone bed ' as the central part of the Fish bed (8 to 10 ft. thick) beneath the Downton Castle building stone ", certainly make it clear that he did not use the Ludlow Bone Bed as a limit of either the Ludlow Rock or the Silurian System, and that the upper limit of the latter was placed at the top of the building stone (12 to 14 ft. thick). He appears, therefore, to have regarded the upper limit of the Ludlow Rock as some 16 to 19 ft. above the Ludlow Bone Bed, but was clearly aware of the transitional nature of the junction. A similar account of the district was given in Murchison's shorter work " Siluria ", first published in 1854.

Murchison (1857 : 290) stated that " the Tilestones of Shropshire and Herefordshire which connect the Silurian and Devonian rocks may, according to the predominance of certain fossils, be classed either with the inferior or the superior system. Their maximum thickness may be considered to be about 40 or 50 ft.".

Shorter contributions on various aspects of the geology of the Ludlow area were made by Murchison (1853), Egerton (1857), Harley (1861), Curley (1863), Lightbody (1863, 1869), Brodie (1869) and Marston (1870).

Wood (1900) established graptolite zones for the Lower Ludlow and discussed the lower and upper limits of Murchison's Lower Ludlow Formation. Whilst pointing out (p. 42) that Murchison drew the base of the Ludlovian " at the Wenlock Limestone ", she put forward the view reached jointly with Elles, that the base of the zone of *Monograptus vulgaris* should be regarded as the Wenlock-Ludlow boundary. As indicated on her Table I, this zone at Ludlow lacks graptolites.

Elles & Slater (1906) classified the highest Silurian rocks of the Ludlow district into :

I. Temeside Group
II. Upper Ludlow Group
III. Aymestry Group

and erected a zonal scheme based on brachiopod species. The Ludlow Bone Bed

was included at the top of II and the Downton Castle Sandstones (see p. 199) " used practically in the same sense as Murchison's Downton Castle Building Stone ", were grouped together with the succeeding Temeside Shales in III, which were regarded as passage beds into the Old Red Sandstone. One effect of this was to place the Silurian-Devonian boundary at the top of the Temeside Shales, about 170 ft above the Ludlow Bone Bed. The area mapped extended from Mocktree Hill to Caynham, but outcrops of formations older than the Aymestry (*Conchidium*) Limestone were omitted.

Alexander (1936) made a study of the Aymestry Limestone of the main outcrop, described its lithology and fauna, and gave an interpretation of the conditions of its deposition. Her table of succession (p. 104) placed the Aymestry Limestone in the zone of *Monograptus leintwardinensis*, but with its base descending in many places into the zone of *Monograptus tumescens*. The *Dayia navicula* beds were shown to rest unconformably on the eroded surface of the Aymestry Limestone. The area mapped extended from Craven Arms, across the Ludlow Anticline to Aymestrey. Outcrops of formations from the Wenlock Limestone to the Lower Whitcliffe (*Rhynchonella nucula*) Beds were shown.

Straw (1927) recorded fish remains from below the Ludlow Bone Bed (Whitcliffe Flags). White (1950 : 58–65) in an analysis of the " vexed question of the Silurian-Old Red boundary ", supported the claims of the law of priority " having regard to the demands of practicability ", and therefore suggested the slight adjustment involved in accepting the Ludlow Bone Bed as the " datum line from which to mark the boundary in other areas ".

The area here described differs somewhat from that covered by Elles & Slater (1906). It extends from the River Teme at Downton Gorge (adjoining the Leintwardine area recently described by Whitaker, 1962), eastwards to Ludlow and then southwards to Richards Castle (adjoining the area mapped by B. J. Williams).

Earlier papers dealt with varying portions of the stratigraphical sequence. The present paper describes the succession from the Wenlock Shales to the base of the Ludlow Bone Bed, here regarded (following White, 1950) as the base of the Old Red Sandstone. Downtonian outcrops are shown on the map only as bounding the area to the north and east.

II. STRATIGRAPHICAL CLASSIFICATION

In erecting a stratigraphical classification for the Ludlow district an attempt has been made to follow the recommendations of the American Commission on Stratigraphic Nomenclature (1961). The particular characteristics of the succession in the Ludlovian rocks of the Welsh Borderland seem to require some modification of the recommended usage.

According to the American Commission the three main categories of stratigraphical divisions are rock-stratigraphical units, biostratigraphical units, and time-stratigraphical units. The divisions in the Ludlow district have been mapped mainly on the basis of their faunal assemblages but lithological characteristics have also proved very helpful in their identification. These units are therefore biostratigraphical and to a lesser extent rock-stratigraphical. If the recommended practice for the

TABLE I.—*Silurian Succession of Ludlow District*

Series	Stage	Local division	Thickness in feet (approx.)	Lithology	Earlier classification
LUDLOVIAN (approximately 1,000 to 1,300 ft.)	WHITCLIFFIAN	Upper Whitcliffe Beds	100	Flaggy calcareous siltstones with shelly limestone bands	Upper Whitcliffe or *Chonetes* Flags
		Lower Whitcliffe Beds	80	Irregularly bedded, massive or thickly flaggy calcareous siltstones	Lower Whitcliffe or *Rhynchonella* Flags
	LEINTWARDINIAN	Upper Leintwardine Beds	5 to 18 (thicker eastwards)	Flaggy calcareous siltstones	Mocktree or *Dayia* Shales
		Lower Leintwardine Beds	100	Thinly flaggy calcareous siltstones	
	BRINGEWOODIAN	Upper Bringewood Beds	40 to 150 (thinner) eastwards)	Irregularly flaggy or nodular silty limestones	Aymestry or *Conchidium* Limestone
		Lower Bringewood Beds	160 to 200 (thicker eastwards)	Flaggy calcareous siltstones with limestone nodules	
	ELTONIAN	Upper Elton Beds	150 to 250	Well bedded, flaggy calcareous siltstones with flaggy limestone bands	Lower Ludlow Shales
		Middle Elton Beds	150 to 350 (thinner eastwards)	Conchoidally fracturing, shaly and thinly flaggy, muddy siltstones	
		Lower Elton Beds	100 to 150	Irregularly bedded, shaly and flaggy, calcareous silty mudstones	
WENLOCKIAN		Wenlock Limestone	200 to 450 (thinner eastwards)	Flaggy silty limestones alternating with calcareous silty shales, 50–60 ft. of nodular limestone at top	Wenlock Limestone
		Wenlock Shales	approx. 1,000 seen	Thinly flaggy, calcareous silty mudstones or calcareous silty shales	Wenlock Shales

former category of unit were observed, they would be called assemblage zones and named after one or more of the characteristic fossils, even though these fossils are not confined to the zone. This would be practicable, although unsatisfactory, for some of the Ludlovian divisions ; but in others no single fossil is sufficiently characteristic or restricted to serve as a label for the whole division. Moreover the taxonomic revision of a fossil name which has been used in this way is liable to cause confusion. This practice may also result in the same fossil name being used in different areas for units which are not even homotaxial. For instance, a study of their complete faunal assemblages indicates that the *Wilsonia* Shales of Builth and the *Wilsonia wilsoni* Grits of Kerry are not biostratigraphical equivalents. To add to the confusion the index fossil is now renamed *Sphaerirhynchia wilsoni* and accordingly the Stratigraphical Code would require the renaming of the unit. In the Ludlow district, in particular, this scheme would result in the resurrection of such names as the *Conchidium knighti* Zone and the *Dayia navicula* Zone, both of which have given rise to confusion. An alternative in this instance would be to call the assemblage zones after localities (e.g. the Bringewood Zone), but this would fail to express the fact that the divisions are partly rock-stratigraphical units. The use of the term " Formation " is intended only for units which are defined essentially on their lithological characteristics. All these considerations seem to justify the use of the non-committal term " Beds " in naming the stratigraphical divisions in the Ludlow district.

This new classification does not render all the more familiar names obsolete but it is necessary to realize their limitations. The term Aymestry Limestone, for instance, refers to a rock-stratigraphical unit. It has been used, and can continue to be used, for the limestone development in the middle of the Ludlovian, even though this limestone is in the Upper Bringewood Beds at Aymestrey and View Edge but in the Lower Leintwardine Beds along Wenlock Edge. Ideally, perhaps, the name Aymestry Limestone should be used only if lithological continuity with the limestone of the type area is proved, but it has also been applied, not unreasonably, to the calcareous developments in a similar stratigraphical position at Usk, Woolhope and Malvern. It cannot logically be applied, however, if the unit passes laterally into strata which are not sufficiently calcareous to justify the use of the term limestone ; this problem arises in the Usk inlier (see p. 148) and to the west of Aymestrey. It should also be remembered that the limestones of the Ludlovian are rarely very pure so that differences of opinion may easily arise as to whether the beds are sufficiently calcareous to justify the term limestone.

Biostratigraphical divisions are usually of more widespread validity than rock-stratigraphical units, particularly if the diagnostic fossils are independent of facies changes. They are also less likely to be diachronic if the characteristic fossils are carefully chosen ; it is very important, however, not to regard faunal units as *necessarily* of time significance merely because more refined criteria are not yet available. In the present mainly biostratigraphical classification the pattern of faunal changes (Text-fig. 1) is strictly applicable only to the shelf region but within that region it facilitates correlation across differing facies. For instance, the Lower Leintwardine Beds near Leintwardine and Downton have previously been called

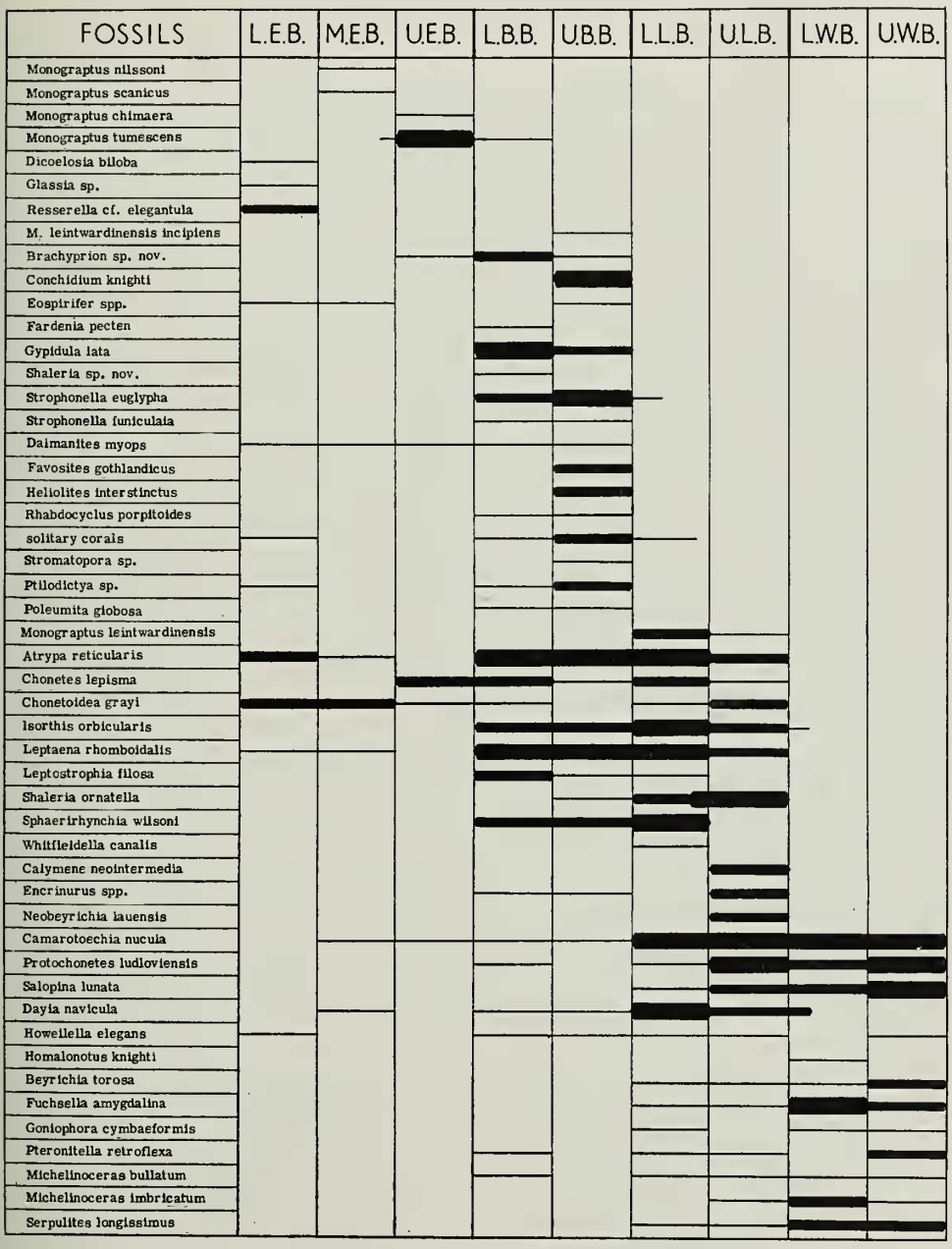


FIG. 1. Range chart of selected Ludlovian fossils. Thin lines indicate " present ", medium lines " fairly common " and thick lines " common ".

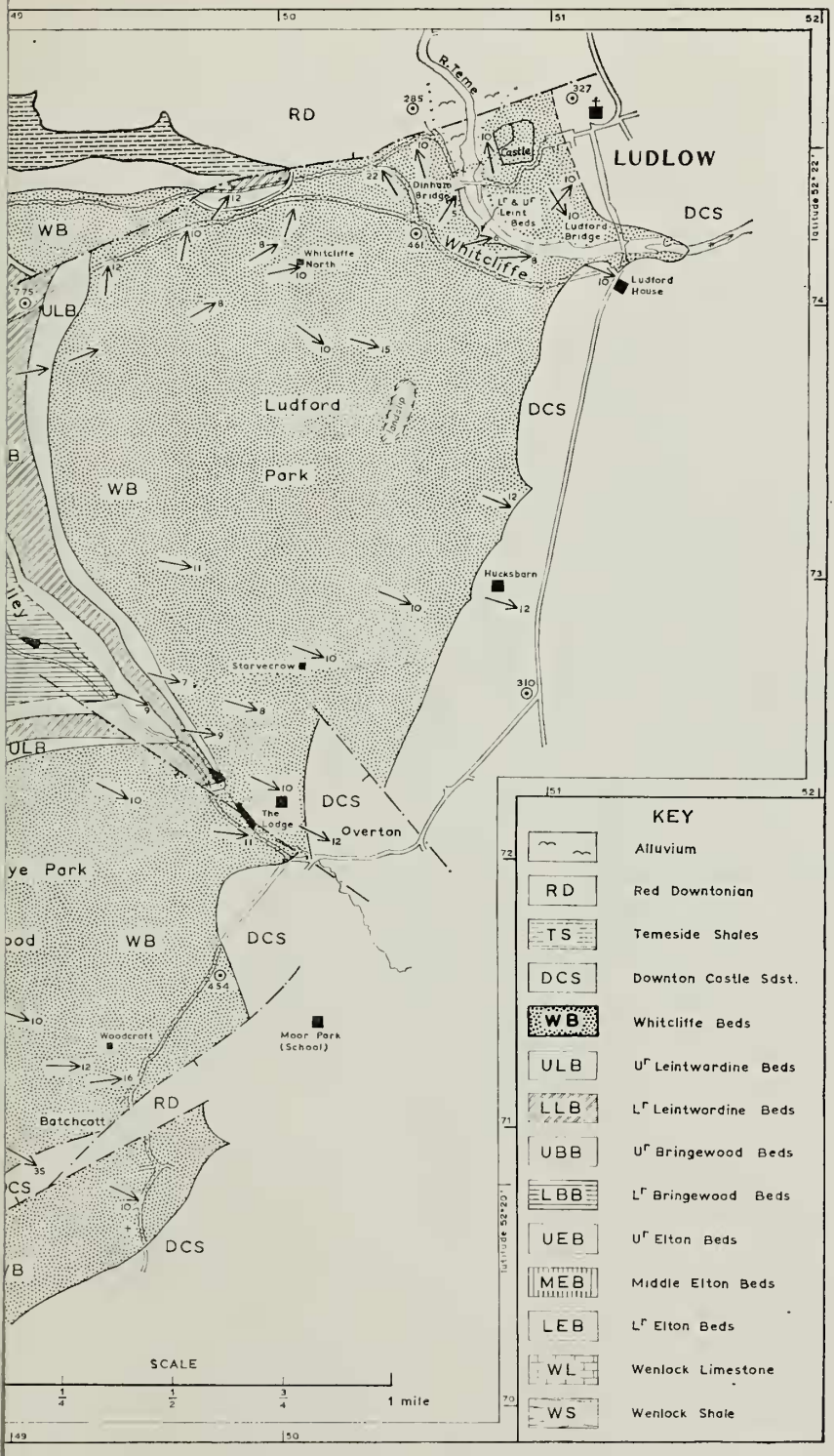
(using a rock-stratigraphical term) Mocktree Shales, whereas strata with a similar faunal assemblage have been called Aymestry Limestone near Ludlow and along Wenlock Edge. Equivalent beds in the basin region are not referred to as Lower Leintwardine Beds because their faunal assemblage is very different from that determined at the standard section. A fairly certain correlation can nevertheless be made based partly on the occurrence of *Monograptus leintwardinensis* and partly on a study of transitional faunas in intermediate areas.

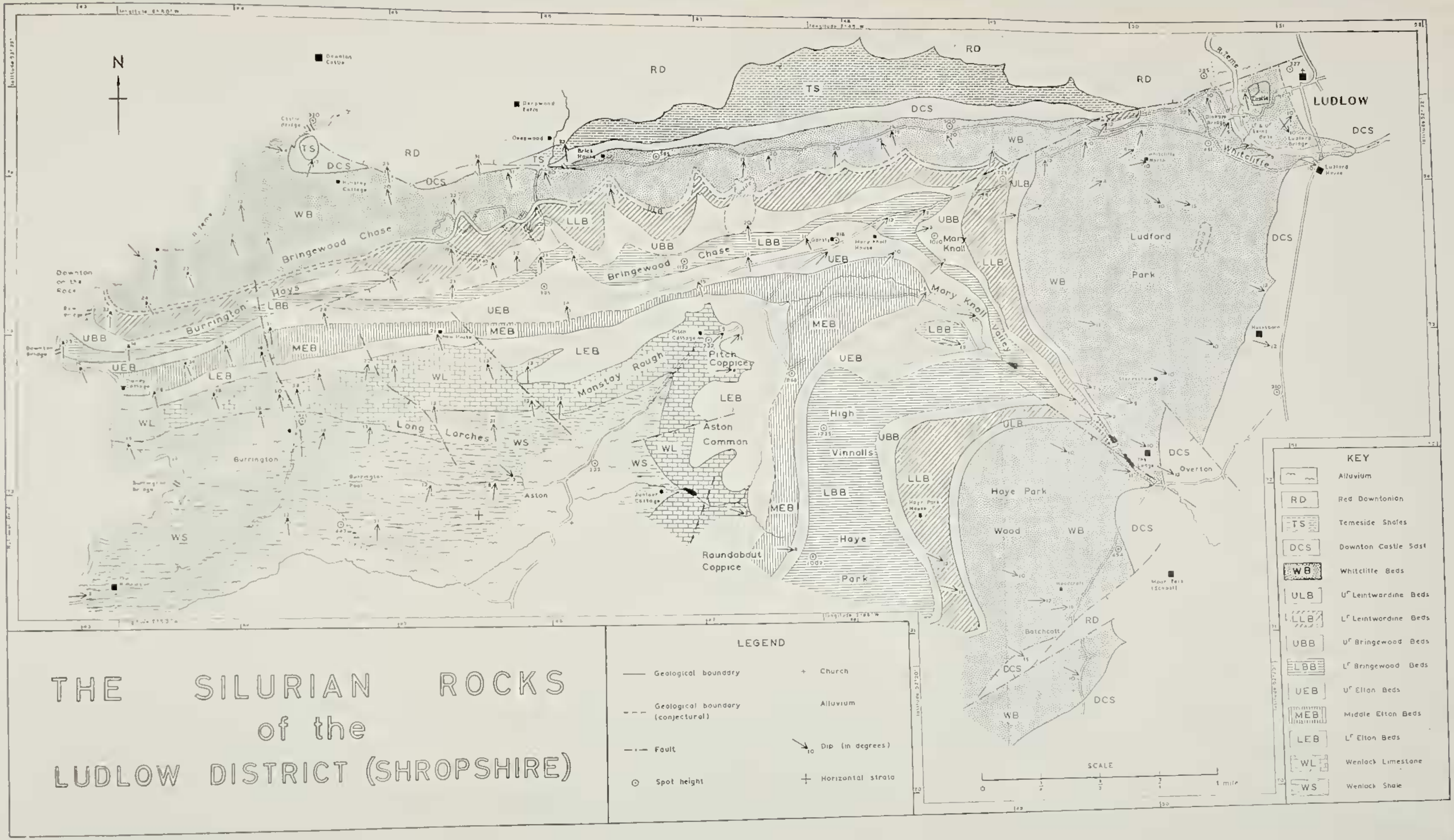
The facies and faunal changes in the basin region are more complex than those on the shelf and in order to simplify the picture a compromise between a rock-stratigraphical and a biostratigraphical classification has again had to be devised (see Table II). Otherwise, most of the present local classifications would have to be used in general discussions on the basin region.

The biostratigraphical divisions of this revised classification for the Ludlow area are here defined at standard localities, the position of each boundary being indicated on a sketch-map or section (except in the case of that between the Lower and Upper Bringewood Beds where this is not necessary). Each boundary is defined by the basal surface of a particular bed and *not* at the parting between beds. Should it be proved at some later time that this parting represents a significant break in deposition at the standard locality any sediments deposited elsewhere during the time represented by this gap will automatically be grouped in the lower unit and will not necessitate the institution of a new division. Although there are distinct faunal and lithological changes at most of the junctions no signs of important breaks have been detected. The bases of the Lower Elton Beds, Lower Bringewood Beds, Lower Leintwardine Beds, and Lower Whitcliffe Beds have been selected as bases of stages.

Even though a refined system of absolute dating is as yet unattained, the stratigrapher must continually be concerned about the *relative* dating of geological events. The ideal correlation is a time correlation. For this purpose a scale of time-stratigraphical units has been evolved, but the smaller these units are, the more difficult is their world-wide recognition. Ideally, there should be only one set of time-stratigraphical units. This ideal is almost realized for the systems but different sets of series tend to be erected for each major region such as a continent. Stages are even more numerous and cover smaller regions ; they are justifiable as a temporary expedient if they link together a variety of local successions into a time-stratigraphical scheme which cannot as yet be linked to the master set of stages in the type area.

As Ludlow is the type area for the Ludlovian Series, the institution of stages needs no further justification, for they become a necessary part of the reference scale of time-stratigraphical units for the whole world. In addition, however, these four stages are needed for linking together the very varied successions in the Ludlovian of the British Isles when discussing palaeogeography, palaeoecology, etc. The only terms hitherto available have been terms such as Lower Ludlovian, Middle Ludlovian, and Upper Ludlovian, which have been used with a confusing variety of meaning. It is here recommended that these terms be abandoned in favour of the fourfold stage classification.


R. Teme
RD
LUDLOW
Castle
Dinham Bridge
LF & UF Leint Beds
Ludford Bridge
DCS
WB
Whitcliffe North
Whitcliffe
Ludford House
ULB
Ludford
Park
Hucksbarn
Starvecrow
The Lodge
Overton
Woodcroft
Moor Park (School)
Batchcott
SCALE
1 mile
KEY
Alluvium
Red Downtonian
Temeside Shales
Downton Castle Sdst.
Whitcliffe Beds
Ur Leintwardine Beds
Lr Leintwardine Beds
Ur Bringewood Beds
Lr Bringewood Beds
Ur Elton Beds
Middle Elton Beds
Lr Elton Beds
Wenlock Limestone
Wenlock Shale


THE SILURIAN ROCKS
of the
LUDLOW DISTRICT (SHROPSHIRE)
N
LUDLOW
Bringewood Chase
Burrington Hays
Monstay Rough
Long Lorches
Pitch Coppice
Aston Common
High Vinnalls
Haye Park
Mary Knoll Valley
Ludford Park
Haye Park Wood
Whitcliffe
Roundabout Coppice
Burrington
Aston
Overton
Batchcott
LEGEND
Geological boundary
Geological boundary (conjectural)
Fault
Spot height
Church
Alluvium
Dip (in degrees)
Horizontal strata
SCALE
0
1 mile
KEY
Alluvium
RD Red Downtonian
TS Temeside Shales
DCS Downton Castle Sdst
WB Whitcliffe Beds
ULB Ur Leintwardine Beds
LLB Lr Leintwardine Beds
UBB Ur Bringewood Beds
LBB Lr Bringewood Beds
UEB Ur Elton Beds
MEB Middle Elton Beds
LEB Lr Elton Beds
WL Wenlock Limestone
WS Wenlock Shale

The stage boundaries have been chosen to coincide with the boundaries of the major biostratigraphical units at the standard sections. Ideally a time-stratigraphical junction should be in a sequence devoid of sudden faunal and lithological changes but the contrasts in this Ludlovian succession are certainly not dramatic enough to justify a separate set of stage boundaries with separate names. Ideally again, the names of the stages should be different from those of the biostratigraphical divisions even though the boundaries are the same, for if it is later proved that the base of, say, the Lower Leintwardine Beds is diachronic they may then be partly of Bringewoodian age and not Leintwardinian. Such a contingency does not seem sufficiently likely to justify the use of separate names for the stages.

The standard sections for the bases of the biostratigraphical divisions are described in Section III unless they are also standard sections for stages in which case they are described in Section VI.

III. DETAILED ACCOUNT OF THE SUCCESSION

In this section the stratigraphical divisions are described in turn. A brief mention of the topographical expression of each, where necessary, is followed by detailed descriptions of lithology and fauna. Then, where applicable, a standard section is described. Finally a list of good exposures is given. Symbols corresponding to the colour terms used in the lithological descriptions have been left out of this section and are listed in Appendix 2, where also is given a list of carbonate determinations for selected samples of the beds. The pattern of faunal changes within the Ludlovian is expressed in the faunal range chart (Text-fig. 1).

In the illustrations of this paper and in the List of Localities (Appendix 1) the following symbols have been used to represent the various stratigraphical divisions :

R.D.	Red Downtonian	L.L.B.	Lower Leintwardine Beds
T.S.	Temeside Shales	U.B.B.	Upper Bringewood Beds
D.C.S.	Downton Castle Sandstone	L.B.B.	Lower Bringewood Beds
B.B.	Ludlow Bone Bed	U.E.B.	Upper Elton Beds
W.B.	Whitcliffe Beds (undifferentiated)	M.E.B.	Middle Elton Beds
U.W.B.	Upper Whitcliffe Beds	L.E.B.	Lower Elton Beds
L.W.B.	Lower Whitcliffe Beds	W.L.	Wenlock Limestone
U.L.B.	Upper Leintwardine Beds	W.S.	Wenlock Shales

(a) *Wenlock Shales*

The outcrop of the Wenlock Shales forms a triangular area of low-lying and predominantly pastoral land in the denuded core of the plunging anticline. It is poorly exposed, except near Burrington and is much covered by alluvium. These beds, at least 1,000 ft. thick, are soft, light olive grey to pale olive, calcareous, thinly flaggy silty mudstones or silty shales, with irregular and infrequent seams of fine-grained nodular limestone. The beds may appear massive to thickly flaggy in fresh exposures, where a large-scale conchoidal fracture is seen. Weathering accentuates the fundamental thinly flaggy or shaly bedding, together with a smaller scale conchoidal fracture and blocky jointing. It also produces colour changes to yellowish

grey, dark yellowish orange, or brownish grey, of which the last is seen especially on joint and fracture faces. Characteristically, weathering produces a light-coloured dusty appearance.

Owing mainly to lack of exposures the Wenlock Shale fauna has not been studied in detail. Small brachiopods and trilobites are the commonest fossils but the numerous shell fragments are not easily identifiable. The more important fossils are as follows :

Dalmanites myops (fairly common)
Chonetoidea grayi
Cyrtia exporrecta
Dicoelosia biloba
Dolerorthis rustica
Calymene sp.
Dalmanites caudatus
Phacops sp.
Hemsiella maccoyana
solitary corals
Dawsonoceras annulatum
Monograptus dubius
—— *vulgaris*
Gothograptus nassa

Selected Localities

Locality 40 : see Section IV (d) page 133
Locality 38 : see Section IV (d) page 133
Locality 61 : see Section IV (d) page 136
Locality 100 : see Appendix 1 page 164
Locality 114 : see Appendix 1 page 165
Locality 141 : see Appendix 1 page 166

(b) *Wenlock Limestone*

The Wenlock Limestone forms wooded scarps which are in places offset along fault-lines. It thins eastwards from 450 to 200 ft. Its base is marked by the relatively sudden occurrence of numerous ribs of hard, irregularly bedded, light olive grey to pale olive, silty limestone, alternating with beds similar to the bulk of the Wenlock Shales. These ribs, which are irregularly and infrequently developed in the Wenlock Shales, form 40% or more of the succession in the Wenlock Limestone, protruding conspicuously in exposures. They weather to a yellowish grey colour or sometimes to the condition of brown rottenstones. In some cases it is evident that the hard ribs represent the coalescence of limestone nodules.

The above description applies to the greater part of the Wenlock Limestone of the district, but the uppermost 50 ft. or so of the formation is predominantly hard nodular limestone. The individual nodules (2 to 8 in. long) are arranged in flaggy units ; they are medium grey when fresh but weather to a yellowish grey. The nodular effect is accentuated by weathering, with the development of softer, dusty looking, surrounds to the nodules (" lenticular " texture of Hadding, 1958).

The limestone is finely crystalline (crystals often about 0·05 mm.) but impure, or may have an obviously important organic content of, for example, of brachiopods, bryozoa, or crinoid fragments. The aggregates of anhedral crystals of calcite in the crystalline limestones are presumably themselves diagenetically recrystallized organic fragments. Bands and concentrations of particular fossils may occur, for example

a band of the coral *Entelophyllum articulatum* at Locality 111. Some *Favosites* and stromatoporoid colonies reach a substantial size; an example of the latter, in position of growth (Locality 65) is 14 in. in diameter and 5 in. in height.

In addition to the dominant nodular limestones there are partings of shaly or irregularly flaggy, silty limestones, light olive grey to pale olive in colour.

Compared with the well-known outcrops on Wenlock Edge and at Dudley, the Wenlock Limestone of the Ludlow area is not very fossiliferous; the corals occur mainly in the more calcareous nodular beds at the top. In the lower flaggy division the most important fossils are as follows:

Atrypa reticularis
Dolerorthis rustica
Eospirifer radiatus
Sowerbyella sp.
Sphaerirhynchia wilsoni
bryozoa

From the nodular division the main elements of the fauna are:

Favosites spp. (fairly common)
Heliolites interstinctus (fairly common)
Thecia grayana
Entelophyllum articulatum
solitary corals
Stromatopora carteri
Atrypa reticularis (fairly common)
Gypidula galeata
Leptaena rhomboidalis (fairly common)
Resserella elegantula
Rhipidomella hybrida
Sphaerirhynchia wilsoni
Strophonella euglypha
Calymene sp.
Dalmanites myops
Poleumita discors
crinoid columnals (common)

Selected Localities

Locality 63 : see Section IV (d) page 136 (lower flaggy limestones)
Locality 65 : see Section IV (d) page 136 (upper nodular limestones)
Locality 14 : see Section IV (b) page 128 (flaggy)
Locality 16 : see Section IV (b) page 128 and Section VI page 139 (upper nodular Wenlock Limestone succeeded by Lower Elton Beds; this is the standard section for the base of the Eltonian).
Locality 140 : see Appendix 1 page 166 (flaggy limestones)
Locality 163 : see Appendix 1 page 166 (nodular)

(c) *Lower Elton Beds*

The softer Lower Elton Beds have been eroded from the underlying Wenlock Limestone to form a step feature or valley, usually unforested. They are approximately 100 to 150 ft. thick and poorly exposed. In sharp contrast to the upper Wenlock Limestone they are soft, pale olive, calcareous, finely micaceous, silty mudstones or muddy siltstones, irregularly bedded in shaly or flaggy units and with a somewhat blocky fracture. They weather towards a dark yellowish brown, but a " greenish " colour speckled white with shell fragments is also characteristic of the beds. The shell fragments are sometimes tightly packed, one within the other. Fresher exposures may appear thickly flaggy, weathering to a more thinly bedded

appearance as well as to a light dusty effect, reminiscent of the Wenlock Shales. In addition to the mudstones and siltstones there are greenish-grey, egg-shaped nodules, rounded slabs and discontinuous bands of hard compact limestone, which tend to be more conspicuous in the lower part of the division.

The Lower Elton Beds are characterized by a shelly fauna of Wenlockian affinities in which small brachiopods and trilobites predominate.

Common or fairly common fossils :

Resserella cf. *elegantula* (not found above these beds)
Atrypa reticularis
Chonetoidea grayi

Less common but important fossils :

Dicoelosia biloba (not found above these beds)
Gypidula galeata, *Plectatrypa imbricata* } (not found above these beds)
Chonetes minimus
Eospirifer plicatellus
Glassia sp.
Howellella elegans
Leptaena rhomboidalis
Dalmanites myops
Hemsiella maccoyana
Halysites catenularius

Alexander (1936) called these " Barren " beds but only because of the absence of graptolites ; small shells and shell fragments are usually abundant although not easily identifiable. Paucity of exposures has resulted in a rather incomplete and possibly unrepresentative faunal list. In adjacent areas and the south-eastern inliers all the species listed as belonging to the Elton Bed fauna (Lawson, 1960 : 116) may occur in these beds.

The standard section for the base of the Lower Elton Beds, which is also that for the base of the Ludlovian Series and the base of the Eltonian Stage, is described in Section VII on pages 139–141.

Selected Localities

Locality 73 : see Section IV (d) page 136
Locality 70 : see Section IV (d) page 136
Locality 69 : see Section IV (d) page 136 and Section III page 107
(Lower Elton Beds succeeded by Middle Elton Beds ; this is the standard locality for the base of the Middle Elton Beds).
Locality 101 : see Appendix 1 page 164
Locality 162 : see Appendix 1 page 166 (base of Lower Elton Beds)

(d) *Middle Elton Beds*

Outcrops of the Middle Elton Beds, which are poorly exposed, form the foot of the

wooded scarps of Bringewood Chase and High Vinnalls. These beds thin appreciably eastwards from approximately 350 to 150 ft. They are well bedded, light olive grey, shaly or thinly flaggy siltstones, with a characteristic, smooth, conchoidal fracture and "soapiness" to the touch. The weathered appearance is yellowish grey with, less commonly, a white dustiness. The well defined bedding planes, paucity of lime, and marked colour changes make these beds clearly distinguishable from the Lower Elton Beds, the transition taking place within a few feet. Less common in the Middle Elton Beds are slightly calcareous, muddy siltstones with some finely divided mica. Occasionally there are papery shales and calcareous nodules. Crinkle marks (Williams & Prentice, 1958) occur rarely and one specimen from these beds (Locality 42) shows a concentration of broken orthoconic nautiloids.

The Middle Elton Beds show a sharp faunal change from the Lower Elton Beds; benthonic forms are rare and graptolites and orthoconic nautiloids predominate.

Common or fairly common fossils:

Monograptus colonus
Chonetoidea grayi
Hemsiella maccoyana
orthoconic nautiloids

Less common but important fossils:

Dayia navicula (not found below these beds)
Lingula lata
Dalmanites myops
Slava interrupta
Monograptus comis
—— *dubius*
—— *nilssoni*
—— *scanicus*
—— *uncinatus* var. *orbatus*
—— *varians*
} (apparently restricted to these beds)
—— *tumescens* (in highest beds only)

These are the Lower Ludlow Shales of the *Monograptus nilssoni* and *M. scanicus* zones of Wood (1900).

The standard section for the base of the Middle Elton Beds is along the stream named Nunfield Gutter (referred to on pages 133 and 136), which flows westwards to join the River Teme near Owney Cottage. This section, about 710 yards east-north-east of Owney Cottage, is on a southward bend in the stream (43897278). Its position is indicated as Locality 69 in the sketch-map (Text-fig. 10) and a detailed plan of the exposures is given in Text-fig. 2. As shown in the latter the boundary follows the stream obliquely across the southern part of the bend and there are exposures in the southern bank which give continuous sections across it. The scale in Text-fig. 2 relates to measurements along the stream. The exposures themselves are shown somewhat diagrammatically.

The lithological change from Lower to Middle Elton Beds is a relatively sharp

one, the transition taking place in about 3 ft. of strata. The irregularly bedded, slightly more thickly flaggy, calcareous siltstones of the Lower Elton Beds, with some limestone nodules, are succeeded by more thinly and better bedded siltstones of the Middle Elton Beds. The change may be seen in the exposures along the stream bank at either A to C or D to E.

The Lower Elton Beds are rich in shelly fossils, though these are often fragmentary. The following were collected from the stream bank at A : *Atrypa reti-*

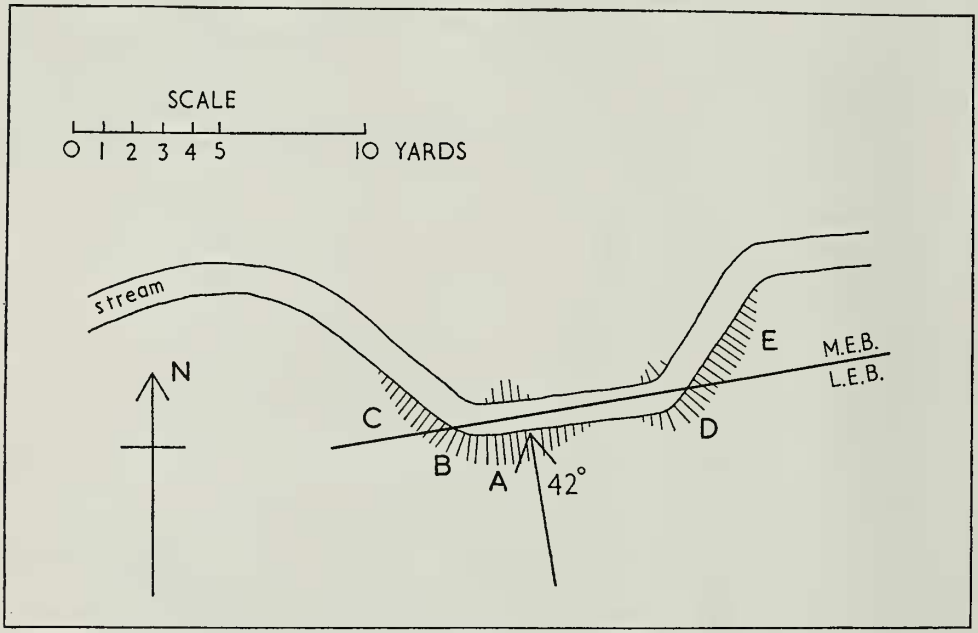


FIG. 2. Plan of the standard locality in Nunfield Gutter for the boundary between the Lower Elton Beds and the Middle Elton Beds (for explanation see p. 107).

cularis, Chonetoidea grayi, Dicoelosia biloba, Glassia sp., *Howellella elegans, Leptaena rhomboidalis, Nuculites* sp., *Pterinea* sp., *Dalmanites myops* and a graptolite fragment. Higher in the stream bank at A is a thin, brown weathering, clay band which may be traced also at the eastern end of the exposure between D and E. The beds (B) up to 13 in. above the clay band yielded graptolite fragments together with *Chonetoidea grayi, Dicoelosia biloba, Glassia* sp., an undetermined lamellibranch, *Michelinoceras* sp., *Dalmanites myops*, a proetid pygidium and an ostracod. The association of more abundant graptolite fragments and fewer shelly fossils, together with the presence of *Dicoelosia biloba* suggests that this is a transitional fauna at the top of the Lower Elton Beds. The base of the Middle Elton Beds has been taken at an horizon 18 in. above the top of the clay band. Above this (C) graptolite fragments, including *Monograptus uncinatus* var. *orbatus* ?, are associated with *Chonetoidea grayi* and *Michelinoceras* sp. About 2 ft. above the boundary the typically thinner and smoother bedding of the Middle Elton Beds is developed.

The graptolites collected from these typical Middle Elton Beds include *Monograptus nilssoni* and *M. uncinatus* var. *orbatus*.

Selected Localities

Locality 75 : see Section IV (d) page 136
Locality 72 : see Section IV (d) page 136
Locality 69 : see Section IV (d) page 136 and Section III page 107
(Middle Elton Beds succeeding Lower Elton Beds ; this is the standard locality for the base of the Middle Elton Beds)
Locality 17 : see Section IV (b) page 128

(e) *Upper Elton Beds*

The Upper Elton Beds near Downton Gorge form a subsidiary feature. Farther east they rise to form the westernmost of the three summits (over 1,200 ft. O.D.) of Bringewood Chase. Elsewhere their outcrop makes a steep wooded slope. The Upper Elton Beds vary in thickness from approximately 150 to 250 ft. In the uppermost part of the Middle Elton Beds the shaly and thinly flaggy siltstones become somewhat harder and calcareous. At the base of the Upper Elton Beds conspicuous ribs of hard, more calcareous siltstone appear and soon become the typical lithology. This typical sediment of the Upper Elton Beds is a well bedded, compact, light olive grey, flaggy, calcareous, coarse siltstone (here, as in all the other Ludlovian siltstones in the succession, the silty material is largely of angular quartz). Shaly and thinly flaggy siltstones are rarer, as are nodular or flaggy limestone bands. The bedding surfaces are characteristically smooth or only slightly irregular. They give a " ringing " effect under the hammer and it is often possible to break off large sheets of rock. There is some lamination shown by slight changes of grain size and layers of greater concentration of dark material together with the angular quartz grains. Weathering reduces the rock first to a yellowish grey and then to dark yellowish-brown. Graptolites and orthoconic nautiloids tend to occur in concentrated patches on certain bedding planes.

Sedimentary structures of various kinds are frequent in the Upper Elton Beds. Both current bedding and slump structures occur and crinkle marks are very common. It is difficult to find accurately orientated specimens as the best exposures are on steep slopes or faces on which slipping has taken place. The few orientated specimens which have been collected from exposures near the River Teme (Locality 43) do not always show a clear overturning of the crinkled laminae. Such measurements as have been made suggest a movement in a south-south-easterly direction, which is directly opposed to that deduced by Williams & Prentice (1958) from exposures in the southern limb of the Ludlow Anticline at the same stratigraphical horizon.

Although the Upper Elton Beds are predominantly graptolitic the varied fauna of the Middle Elton Beds has disappeared and *Monograptus tumescens* is the only common graptolite.

Common or fairly common fossils :

Monograptus tumescens
Chonetes lepisma (locally fairly common)
orthoconic nautiloids

Less common but important fossils :

Brachyprion sp. nov.
Chonetoidea grayi
Lingula lata
Dalmanites myops
Monograptus chimaera

These are the Lower Ludlow Shales of the zone of *Monograptus tumescens* as described by Wood (1900).

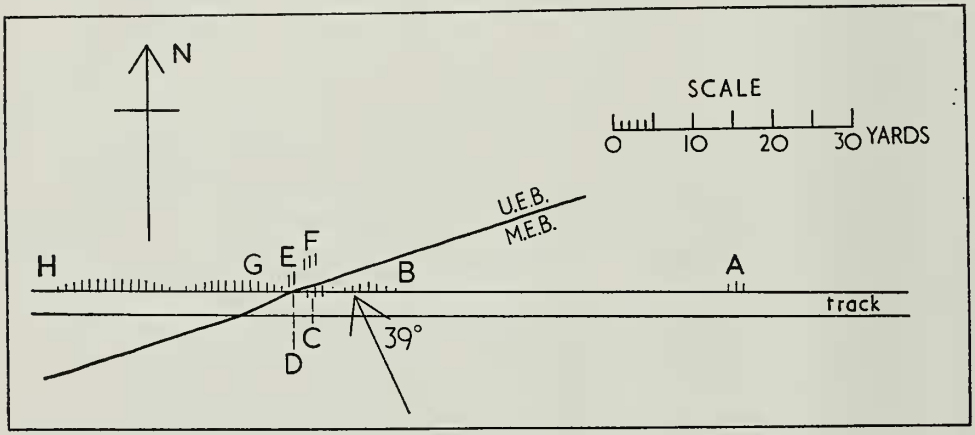


FIG. 3. Plan of the standard locality near Owney Wood for the boundary between the Middle Elton Beds and the Upper Elton Beds (for explanation see below).

The standard locality for the base of the Upper Elton Beds is along the north side of the track which climbs obliquely across the lower part of the scarp north-east of Owney Wood. The grid reference is 43677283 and its position is shown as Locality 76 in Text-fig. 10. A detailed plan of the exposures along the track is given in Text-fig. 3. Point D, where the base of the Upper Elton Beds crosses the north margin of the track, lies 239 yards from the gate post (43887280) at the foot of the track, and 238 yards from the gateway (43527284) at the top where the track enters the upper part of Owney Wood.

Though the Middle and Upper Elton Beds have different graptolite faunas they are most easily distinguished in the field by their characteristic lithologies. In this section, which is one of the few in which strata close to the boundary are exposed, a lithological transition is seen between the two divisions. The base of the Upper Elton Beds has been taken near the first of the hard calcareous flaggy ribs which characterize these beds.

Details of the section are as follows : ascending the track from the gatepost previously mentioned, the first exposures occur after 183 yards at point A, where fairly typical Middle Elton Beds are seen. These are relatively soft, mostly shaly

siltstones (not calcareous) showing characteristic conchoidal fracture and weathering to a slightly yellowish colour. *Monograptus varians* was collected here, together with *Chonetoidea grayi* and *Michelinoceras* sp.

The beds exposed at point B, though still mostly shaly, are harder than typical Middle Elton Beds and slightly calcareous. *Monograptus tumescens* was collected here so that, in this section at least, this graptolite appears before the typical lithology of the Upper Elton Beds. Also present are *Kionoceras angulatum* and *Michelinoceras* spp. At point C, immediately below the chosen boundary, the same lithology is maintained. *Michelinoceras* sp. is present together with fragments of graptolites and shelly fossils.

At point E the hard shaly and thinly flaggy siltstones are associated with the first prominent flaggy ribs of very hard calcareous siltstone. The base of the Upper Elton Beds has therefore been taken between C and E (i.e. at point D). *Monograptus tumescens* was collected from E. Similar beds at about the same horizon are poorly exposed at point F, in the north-western corner of an overgrown excavation a few yards north of the track. At point G, along the track again and farther west, *M. tumescens*, associated with *Chonetoidea grayi* was again collected. Flaggy ribs are more common here and at the western end of the exposures (point H) are sufficiently prominent for the lithology to be recognized as fairly typical of the Upper Elton Beds. *M. tumescens* is common here and a pygidium of *Dalmanites myops* has been collected.

Selected Localities

Locality 43 : see Section IV (d) page 133
Locality 107 : see Appendix 1 page 165
Locality 18 : see Section IV (b) page 128
Locality 170 : see Appendix 1 page 167
Locality 164 : see Appendix 1 page 166
Locality 165 : see Appendix 1 page 166

(f) *Lower Bringewood Beds*

The crest of the Ludlovian scarp feature of High Vinnalls and the eastern summits of Bringewood Chase are formed by Lower Bringewood Beds which also extend in places some way down the dip slope. These beds thicken slightly eastwards, from approximately 160 to 200 ft. Their base is marked by the appearance of many bands of shelly fossils, by more frequent bands and lenses of silty limestone, and by the development of calcareous siltstones somewhat thicker and more irregularly bedded than those of the Upper Elton Beds, which they quickly replace. These irregularly bedded, calcareous, finely micaceous, medium-coarse siltstones are light olive grey in colour, sometimes weathering to pale olive. Some of the more calcareous siltstones are medium grey when fresh, but weather to a brown rottenstone, as do some of the shelly limestone bands.

The Lower Bringewood Beds show a marked faunal contrast to the Upper Elton Beds; graptolites and orthoconic nautiloids are rare, whereas large brachiopods (particularly strophomenids) are abundant. In the Ludlow area the faunal change is accentuated

because of this change from a graptolitic to a shelly facies, but even in those areas where the equivalents of the Elton Beds have a more benthonic fauna the change is distinct. The disappearing Elton Bed fauna has been listed by Lawson (1960 : 116). Most of the typical Bringewood Bed fossils are familiar Wenlockian species returning with the change to shallow water and calcareous conditions.

Common or fairly common fossils :

Brachyprion sp. nov.
Leptostrophia filosa
Dalmanites myops
} (Less common in Upper Bringewood Beds)
Atrypa reticularis
Chonetes lepisma
Gypidula lata
Howellella elegans
Isorthis orbicularis
Leptaena rhomboidalis
Sphaerirhynchia wilsoni
Strophonella euglypha
bryozoans

Less common but important fossils :

Protochonetes ludloviensis (not found below these beds)
Fardenia pecten
Shaleria sp. nov.
} (not found above these beds)
Dayia navicula
Strophonella funiculata
Cypricardinia spp.
Liospira striatissima
Poleumita globosa
Rhabdocyclus porpitoides
solitary corals

These distinctive beds have not previously been separated and appear to have been hitherto included with the Aymestry Limestone because of their faunal affinities.

The standard section for the base of the Lower Bringewood Beds, which is also that for the base of the Bringewoodian Stage, is described in Section VI, p. 141.

Selected Localities

Locality 44 : see Section IV (d) page 133
Locality 19 : see Section IV (b) page 128
Locality 33 : see Section IV (c) page 131

(g) *Upper Bringewood Beds*

These beds have been called Aymestry Limestone in previous papers. The assumption that the limestone gives rise to the Ludlovian scarp feature is mostly

incorrect in this area ; it does so only in the extreme west and at Mary Knoll. The Upper Bringewood Beds have a maximum thickness of about 150 ft. in the west of the Ludlow district at Downton Gorge, from which they thin eastwards to a minimum of approximately 40 ft. The change from Lower to Upper Bringewood Beds, relatively sharp in the west but more gradual in the east, involves an increased proportion of harder limestone over calcareous siltstone. The typical Upper Bringewood Beds are irregularly bedded, flaggy, silty limestones or irregularly flaggy to nodular, crystalline limestones. Shell bands of *Conchidium knighti* are fairly common, the limestones are sometimes crinoidal, and in places tabulate corals are common. There are thin shaly partings at intervals of several feet.

The fresh limestone is medium grey, weathering to light olive grey ; this latter colour also characterizes the more silty limestone. Some of the more calcareous beds may weather to brown rottenstone. The nodular limestones, with the surrounds to the nodules softened by weathering, assume the " lenticular " texture previously referred to under the Wenlock Limestone.

The fauna of the Upper Bringewood Beds is substantially similar to that of the lower division but strophomenid brachiopods are less abundant, whereas *Conchidium knighti* and compound corals become common.

Common or fairly common fossils :

Conchidium knighti (found only in these beds)
Favosites gothlandicus } (not found above these beds)
Heliolites interstinctus }
Gypidula lata }
Strophonella euglypha } (very rare above these beds)
solitary corals }
Atrypa reticularis
Camarotoechia nucula
Isorthis orbicularis
Leptaena rhomboidalis
Sphaerirhynchia wilsoni
crinoid columnals

Less common but important fossils :

Brachyprion sp. nov. }
Eospirifer plicatellus }
—— *radiatus* }
Strophonella funiculata }
Dalmanites myops } (not found above these beds)
Liospira striatissima }
Poleumita globosa }
Rhabdocyclus porpitoides }
stromatoporoids }
Dayia navicula
Monograptus leintwardinensis var. *incipiens* (in higher beds)
Ptilodictya lanceolata

These beds constitute the familiar Aymestry Limestone of View Edge and Aymestrey ; much of the Aymestry Limestone along Corvedale, however, comprises calcareous Lower Leintwardine Beds.

The standard locality for the base of the Upper Bringewood Beds is at Grid Reference 45957352, where the $2\frac{1}{2}$-Inch (1 : 25000) and 6-Inch O.S. maps show the main source of the stream named Raddle Brook, which flows northwards down the dip slope to join the River Teme about 1,000 yards north-east of Bringewood Forge Bridge. Below this locality the slope of the ground is less than the dip and for about 100 yards the rocky bed of the stream provides a more or less continuous exposure through almost the whole succession of the Upper Bringewood Beds. The base of these hard lime stones causes a distinct change of slope, at which the base of the Upper Bringewood Beds has been taken in the stream profile, and to the south of this (i.e. upstream) is a broader, flat area of the stream bed, about 7 yards in length, on the outcrop of the Lower Bringewood Beds. Above this (at the south side) a low cliff about 4 ft. high exposes the top part of these beds. There is a spring below the cliff, but a lesser stream course descends the higher part of the forested slope and enters the flat area near the spring by a short " waterfall " to the west of the small cliff. Lower Bringewood Beds are also exposed in this " waterfall " and about 10 yards up the stream course above it.

The small cliff exposure shows the typical lithology of the Lower Bringewood Beds, with their thickly flaggy to massive calcareous siltstones and some limestone nodules or lenses. In contrast the Upper Bringewood Beds are hard flaggy limestones exposed as a series of bedding planes in the stream.

Both divisions are highly fossiliferous, though the Lower Bringewood Beds are not altogether typical because of an unusual abundance of gastropods and the apparent absence of *Gypidula lata, Strophonella euglypha* and *Strophonella funiculata.* The occurrence of *Brachyprion* sp. nov. at this exposure is therefore important. From the basal Upper Bringewood Beds the diagnostic fossils *Conchidium knighti* and *Favosites* were collected. The complete fauna collected from the Lower Bringewood Beds in the small cliff and adjacent " waterfall " is as follows : *Atrypa reticularis, Howellella elegans, Isorthis orbicularis, Sphaerirhynchia wilsoni* and flat gastropods (all common fossils) ; *Chonetes lepisma, Leptostrophia filosa* and *Cypricardinia subplanulata* (all fairly common) ; *Brachyprion* sp. nov., *Craniops implicata, Dayia navicula, Leptaena rhomboidalis,* bryozoans, *Cypricardinia planulata, Pterinea sowerbyi, " Murchisonia "* sp., a turreted gastropod, *Cornulites serpularius,* a trilobite hypostoma and fragment, *Hemsiella maccoyana* ?, *Primitia* sp. and a crinoid columnal.

From the basal foot of the Upper Bringewood Beds in the stream bed the following were collected : *Favosites* sp., solitary coral, *Atrypa reticularis, Camarotoechia nucula, Chonetes lepisma, Conchidium knighti, Lingula lewisi* (several, in position of growth), *Sphaerirhynchia wilsoni, Strophonella euglypha* (very common), a flat gastropod, *Dalmanites myops* and crinoid columnals. Additional fossils collected from higher in the sequence further down the stream are as follows : bryozoa, *Gypidula lata, Leptaena rhomboidalis* and " *Murchisonia* " sp.

Selected Localities

Locality 45 : see Section IV (d) page 134
Locality 77 : see Section IV (d) page 138 (Upper Bringewood Beds succeeded sharply by Lower Leintwardine Beds)
Locality 127 : see Appendix 1 page 165 (joint surfaces exposed by landslipping c.f. Locality 22)
Locality 23 : see Section IV (b) page 128
Locality 22 : see Section IV (b) page 128
Locality 20 : see Section IV (b) page 128
Locality 35 : see Section IV (c) page 131

(h) *Lower Leintwardine Beds*

The outcrop of the Lower Leintwardine Beds generally forms the higher part of the dip slope, but at the eastern end of Burrington Hays, as a result of faulting, these beds form the crest of the scarp. The main Ludlovian feature may thus be formed by any one of four stratigraphical divisions, Upper Elton Beds, Lower Bringewood Beds, Upper Bringewood Beds or Lower Leintwardine Beds.

The Lower Leintwardine Beds are approximately 100 ft. thick. In the western part of the district, towards Downton Gorge (e.g. Text-fig. 10, Locality 40) the lithological change from the nodular limestones of the Upper Bringewood Beds is clear and sharp. The Lower Leintwardine Beds here are light olive grey, calcareous, thinly flaggy and shaly, medium-coarse siltstones, with thinly flaggy shelly limestones. Weathering gives a dusty yellowish grey appearance, with the shelly limestones forming dark yellowish-brown rottenstones.

Elsewhere, for example in the standard section for the basal boundary (Locality 30) described on pp. 141–145, the Lower Leintwardine Beds begin with somewhat nodular, irregularly bedded, massive or thickly flaggy limestones. These are followed by better and more thinly-bedded calcareous siltstones, similar to those in the west but richer in calcium carbonate and with a characteristic honeycomb weathering.

In the Lower Leintwardine Beds the characteristic fossils of the Bringewood Beds (see Lawson, 1960 : 117–118) are either absent or very rare, even though the facies contrast is not at all strong near Ludlow itself. Brachiopods remain the dominant fossils.

Common or fairly common fossils :

Monograptus leintwardinensis (not found below these beds)
Sphaerirhynchia wilsoni (not found above these beds)
Chonetes lepisma (not common above these beds)
Atrypa reticularis
Camarotoechia nucula
Dayia navicula
Isorthis orbicularis
Leptaena rhomboidalis
Shaleria ornatella (common in the higher beds)
bryozoans
crinoid columnals (at base)

Less common but important fossils :

Salopina lunata
Serpulites longissimus } (not found below these beds)
Beyrichia kloedeni var. *torosa*
Protochonetes ludloviensis
Lingula lata
proetid trilobite (in highest beds)
Fuchsella amygdalina

There is a distinct change of emphasis in the fauna from east to west, presumably related to the facies change as the muddier and less calcareous basin region is approached. In the west of the area *Dayia navicula*, *Lingula lata* and *Monograptus leintwardinensis* are commoner than in the east but *Atrypa reticularis*, *Camarotoechia nucula*, *Shaleria ornatella* and *Sphaerirhynchia wilsoni* are correspondingly less common. The authors are indebted to Dr. E. V. Tucker for more detailed confirmation of these changes.

These beds are roughly equivalent to the *Dayia* or Mocktree Shales of Elles & Slater (1906).

The standard section for the base of the Lower Leintwardine Beds, which is also that for the base of the Leintwardinian Stage, is described in Section VI on pp. 141–145.

Selected Localities

Locality 77 : see Section IV (d) page 138 (basal Lower Leintwardine Beds of typical western facies following sharply upon limestones of Upper Bringewood Beds)
Locality 129 : see Appendix 1 page 165 (higher part of Lower Leintwardine Beds ; *Monograptus leintwardinensis* common)
Locality 24 : see Section IV (b) page 128 (basal Lower Leintwardine Beds of eastern facies)
Locality 25 : see Section IV (b) page 129 (uppermost Lower Leintwardine Beds)
Locality 261 : see Appendix 1 page 169

(i) *Upper Leintwardine Beds*

In the eastern part of the district, for example in the standard section on the Whitcliffe (see p. 117), the Upper Leintwardine Beds show the same thinly bedded calcareous siltstones, with their characteristic honeycomb weathering, as are found in the bulk of the Lower Leintwardine Beds. Their thickness here reaches a maximum value of 18 ft. Only in the top few feet does the bedding become pronouncedly thicker as in the succeeding Lower Whitcliffe Beds.

In the west, the Upper Leintwardine Beds (only about 5 ft. thick) form lithologically more of a transitional group, resembling the succeeding Lower Whitcliffe Beds rather than the Lower Leintwardine Beds. Here they are irregularly bedded, light olive grey or pale olive, somewhat micaceous and calcareous, flaggy medium siltstones. These weather to pale yellowish brown or yellowish grey. Thin shelly

layers, commonly in a rotten, biscuity condition and dark yellowish brown in colour are characteristic of the western exposures.

The fauna of the Upper Leintwardine Beds combines most of the fauna of the lower division with the increased abundance of the incoming Whitcliffe Bed fossils (Lawson, 1960 : 119). In addition there are several fossils common only in these beds.

Common or fairly common fossils :

Neobeyrichia lauensis (found only in these beds)
Calymene neointermedia } (fairly common only in these beds)
Encrinurus sp. }
Atrypa reticularis }
Chonetoidea grayi } (not found above these beds)
Leptaena rhomboidalis }
Shaleria ornatella }
Isorthis orbicularis (rare above these beds)
Camarotoechia nucula
Protochonetes ludloviensis
Dayia navicula
Salopina lunata
bryozoans

Less common but important fossils :

Chonetes lepisma (not found above these beds)
proetid trilobite
Beyrichia kloedeni var. *torosa*
Monograptus leintwardinensis
Cornulites serpularius

In the west of the area where these beds are less calcareous they are characterized by thin, dark brown, biscuity layers crowded with weathered specimens of *Chonetoidea grayi* and *Neobeyrichia lauensis* and often containing *Dayia navicula*, *Calymene neointermedia* and *Encrinurus* sp. Such a development is typical of the *lauensis* Beds of the basin facies. In the east, around Ludlow itself, these bands are less common and the Upper Leintwardine Beds are not so readily distinguished from the Lower Leintwardine Beds. This important division was not recognized by previous authors but appears to have been for the most part included in the *Dayia* or Mocktree Shales of Elles & Slater (1906).

The standard section for the base of the Upper Leintwardine Beds is at Locality 3 on the sketch-map of the Whitcliffe (Text-fig. 7). The map-reference is 50717428 and the line X indicates the position of the section in the sketch of the cliff (Text-fig. 4). In the diagram of the vertical section (Text-fig. 5) A and B comprise hard flaggy calcareous siltstones separated by a thin shale two feet above ground level. The fairly common fossils are *Atrypa reticularis*, *Camarotoechia nucula*, *Dayia navicula*, *Leptaena rhomboidalis*, *Shaleria ornatella* and *Monograptus leintwardinensis*.

"*Dalmanella*" sp., *Lingula lata*, a proetid trilobite and *Goniophora cymbaeformis* have also been found. C is a calcareous siltstone band from one to one and a half inches thick which occurs immediately below a recess formed by the weathering back of a shaly layer. Almost at the base of C there is a thin fossiliferous seam which has yielded *Calymene neointermedia*, *Encrinurus* sp. and *Chonetoidea grayi*, a fauna here taken to define the Upper Leintwardine Beds. Of other fossils, *Shaleria*

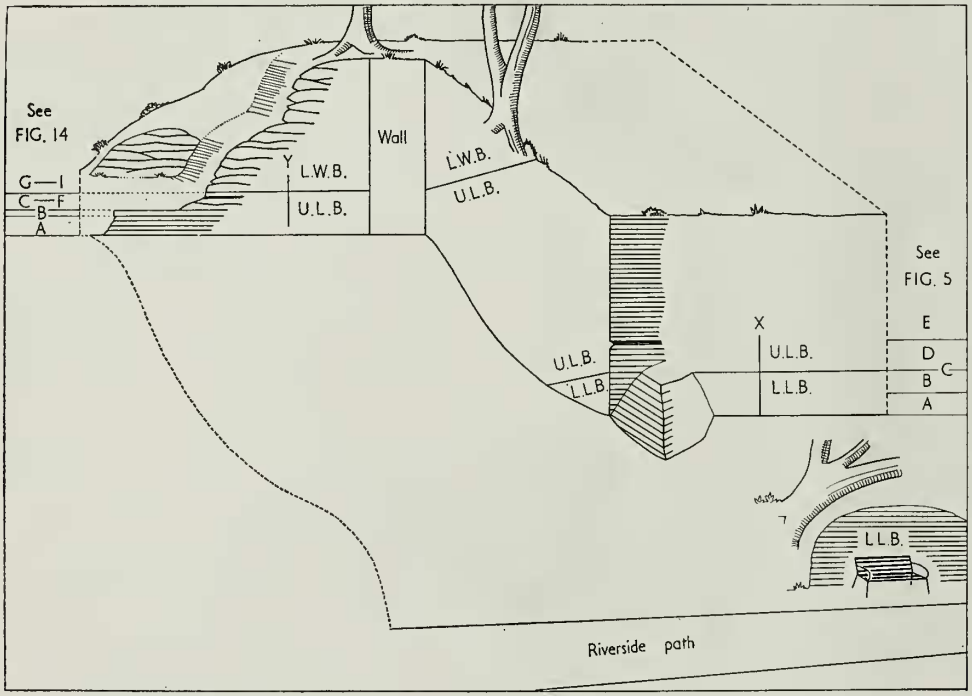


FIG. 4. Sketch of part of the Whitcliffe showing the positions of the standard sections for the boundary between the Lower Leintwardine Beds and the Upper Leintwardine Beds (marked X), and the boundary between the Upper Leintwardine Beds and the Lower Whitcliffe Beds (marked Y). For explanation and reference to other illustrations see pp. 117 and 145.

ornatella is common and *Atrypa reticularis*, *Chonetes lepisma*, *Camarotoechia nucula*, "*Dalmanella*" sp., *Dayia navicula*, *Leptaena rhomboidalis*, *Lingula lata*, a proetid, *Fuchsella amygdalina*, and *Monograptus leintwardinensis* also occur. Some phosphatized fragments have been noted. The base of the Upper Leintwardine Beds is defined by the bottom of this bed C. It is succeeded by flaggy calcareous siltstones, some of which display small-scale current bedding. The highest beds of D are more shaly and form a recess which is particularly marked in the middle section of the cliff face which runs at right angles to the river.

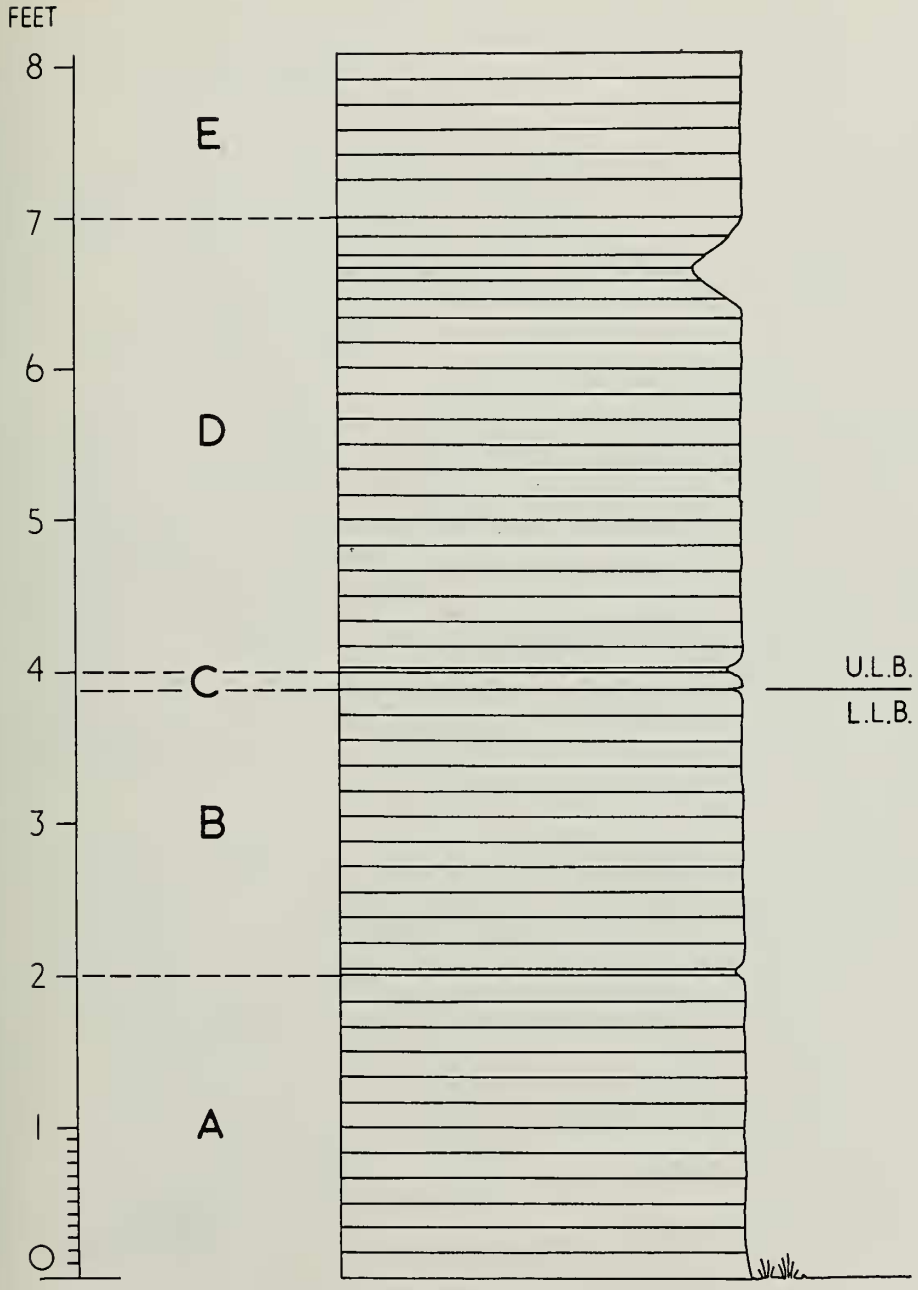


FIG. 5. Diagrammatic section showing the position of the boundary between the Lower Leintwardine Beds and the Upper Leintwardine Beds on the Whitcliffe (for explanation see p. 117).

Selected Localities

Locality 121 : see Appendix 1 page 165 (Upper Leintwardine Beds of western facies with bands of *Chonetoidea grayi* and *Neobeyrichia lauensis*)
Locality 125 : see Appendix 1 page 165 (western facies)
Locality 129 : see Appendix 1 page 165 (discontinuous trackside exposure with Lower Leintwardine Beds to south and Lower Whitcliffe Beds to north ; western facies of Upper Leintwardine Beds)
Locality 26 : see Section IV (b) page 129 (facies of intermediate character with *Shaleria ornatella*, trilobites and *Neobeyrichra lauensis*)
Locality 27 : see Section IV (b) page 129 (as above)
Locality 11 : see Section IV (a) page 126 (eastern facies without *Neobeyrichia lauensis*)

(j) *Lower Whitcliffe Beds*

Extensive outcrops of Whitcliffe Beds form the lower dip slopes round the plunging Ludlow Anticline. The Lower Whitcliffe Beds, approximately 80 ft. thick, are irregularly bedded, massive or thickly flaggy, more or less micaceous, somewhat calcareous, coarse to medium siltstones, with a large scale conchoidal or crudely blocky fracture. In colour they vary from medium grey in the fresh, more calcareous beds to shades of greenish grey and light olive grey. Weathering eventually produces a dusky yellow appearance. There are some shaly partings and some smoothly bedded, thinly flaggy siltstones. Calcareous nodules are present and may reach about 12 in. in size. The massive appearance of the beds is noticeable in the steeper part of Downton Gorge, in parts of the Whitcliffe and in various old quarries throughout the district. In smaller exposures the relatively thick bedding and the crude irregularity of both bedding and fracture are often conspicuous.

The base of the Lower Whitcliffe Beds cannot be precisely recognized lithologically as some of the characteristic features are developed in part at least of the Upper Leintwardine Beds. Slump bedding is rare within the group, but the top is marked by the " Concretion-Band " of Elles & Slater (1906), a slump band about 9 to 18 in. in thickness which is exposed at various points within the district (e.g. Whitcliffe, Clive Cottages Quarry, Downton Gorge). The band shows considerable variation in both the intensity and character of the slumping and in some cases (e.g. Downton Gorge and see also Whitaker, 1962) there are several such bands close together. That the band is not in fact " concretionary " is shown by the bending over of shell bands in response to the slump folds.

Most of the elements of the Leintwardine Bed fauna (Lawson, 1960 : 119) disappear at the base of the Lower Whitcliffe Beds but rare survivors may be found. In the Whitcliffe Beds as a whole, brachiopod species, particularly articulate forms, are few ; mollusca become relatively more important, annelids are fairly common, but no graptolites have been found. In the Lower Whitcliffe Beds fossils are not abundant.

Common or fairly common fossils :

Dayia navicula (in lower beds only : not found above)

Camarotoechia nucula
Protochonetes ludloviensis (often of small size)
Salopina lunata
Fuchsella amygdalina
Michelinoceras imbricatum
Serpulites longissimus

Less common but important fossils :
Homalonotus knighti
Beyrichia kloedeni var. *torosa*
Nuculites spp.
Michelinoceras bullatum

These beds are the Lower Whitcliffe or *Rhynchonella* Flags of Elles & Slater (1906).

The standard section for the base of the Lower Whitcliffe Beds, which is also that for the base of the Whitcliffian Stage, is described in Section VI on pp. 145–146.

Selected Localities

Locality 49 : see Section IV (d) page 134
Locality 50 : see Section IV (d) page 134
Locality 53 : see Section IV(d) page 134 (Lower Whitcliffe Beds succeeded by Upper Whitcliffe Beds ; good exposure of slump structures at top of lower division)
Locality 28 : see Section IV (b) page 129
Locality 8 : see Section IV (a) page 126
Locality 29 : see Section IV (c) page 129 (*Dayia navicula* fairly common)

(k) *Upper Whitcliffe Beds*

The Upper Whitcliffe Beds are approximately 100 ft. thick. The slump band which is taken as the top of the Lower Whitcliffe Beds coincides approximately with a change in lithology from the thicker and more irregular bedding seen below. In the absence of the marker band it would be difficult to select a precise lithological boundary within the transitional strata. The typical Upper Whitcliffe Beds are well bedded, pale olive to light olive grey. more or less micaceous, clean, well sorted, medium to coarse siltstones. There are more prominent, compact, flaggy calcareous beds within the slightly more irregular flaggy and shaly siltstones. There is often a laminated appearance, related to a smaller scale development of more calcareous layers. Shelly limestones are commonly present. Weathering produces a characteristic dusky yellow colour, with the more calcareous beds and laminae, together with the shelly limestones, often reduced to dark yellowish brown rottenstones. Small-scale false bedding is frequently developed and there are occasional slump bands, notably an apparently impersistent thin bed about 11 ft. from the base.

Fossils are commoner in the Upper Whitcliffe Beds than in the lower division, brachiopods, *Salopina lunata* in particular, being more abundant.

Common or fairly common fossils :
Camarotoechia nucula *Beyrichia kloedeni* var. *torosa*

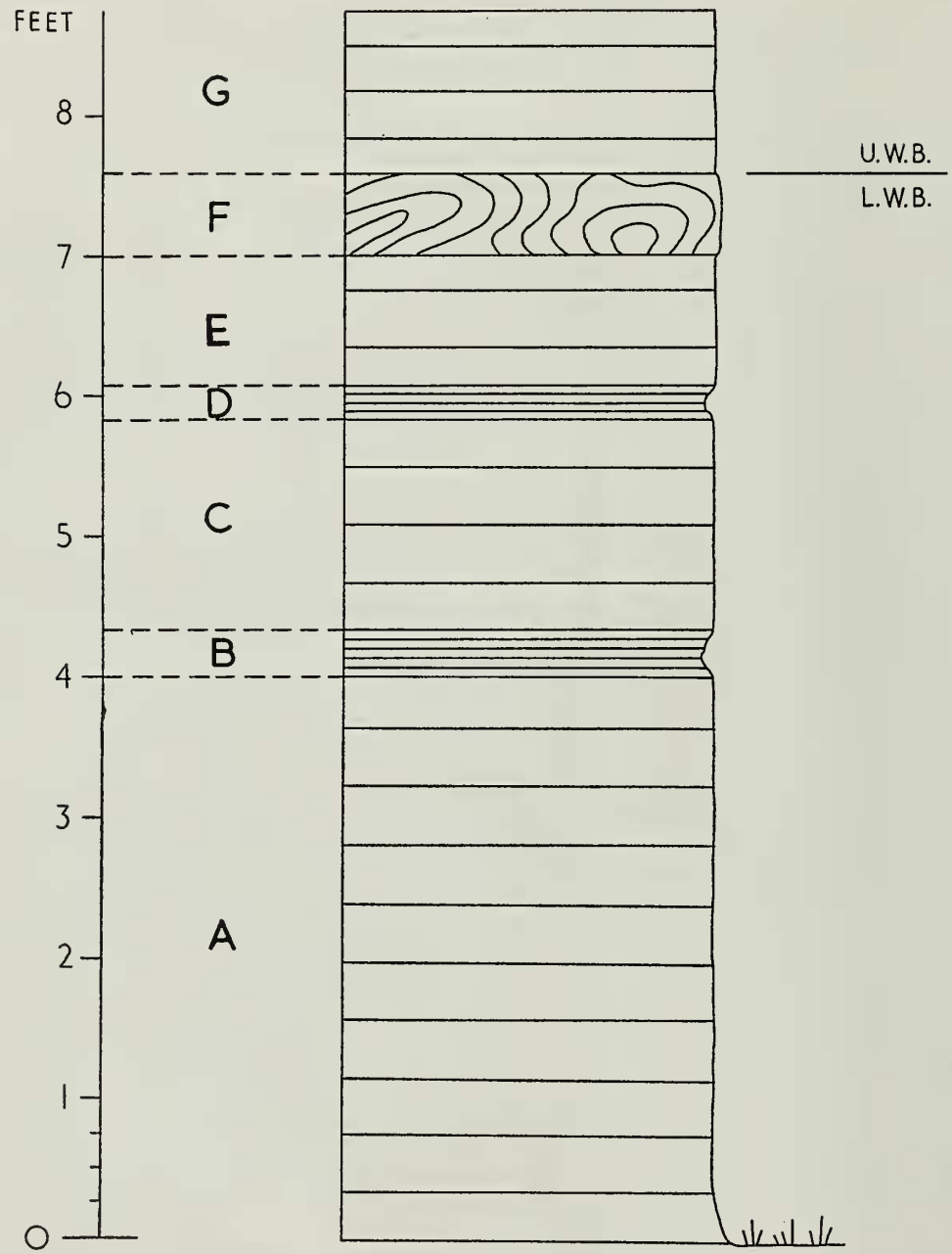


FIG. 6. Diagrammatic section showing the position of the boundary between the Lower Whitcliffe Beds and the Upper Whitcliffe Beds in the Whitcliffe Quarry (for explanation see p. 123).

Protochonetes ludloviensis
Howellella elegans (in highest beds)
Salopina lunata
Fuchsella amygdalina
Pteronitella retroflexa
Serpulites longissimus

Less common but important fossils :

Craniops implicata
Orbiculoidea rugata
Acastella cf. *spinosa*
Nuculites spp.
Loxonema sp.
Michelinoceras bullatum
—— *imbricatum*
Cornulites serpularius

These beds constitute the Upper Whitcliffe or *Chonetes* Flags of Elles & Slater (1906).

The standard locality for the base of the Upper Whitcliffe Beds is the well known old quarry face (50947414) on the Whitcliffe, about 350 yards west-south-west of Ludford Bridge. The quarry is shown as Locality 6 on the sketch-map (Text-fig. 7), and a diagrammatic vertical section of the lower part of the face is given in Text-fig. 6.

Although typical Lower and Upper Whitcliffe Beds can be readily distinguished lithologically (pp. 120, 121), rock types characteristic of each division may occur in the other, making identification in small exposures uncertain. There is also a stratigraphical transition between the two divisions. The faunal differences between them (pp. 120, 123) are slight and depend upon the abundance of certain forms in the Upper Whitcliffe Beds rather than upon the presence of any diagnostic species Accordingly an arbitrary line must be taken as the base of the Upper Whitcliffe Beds and it is appropriate that this should coincide with that chosen by Elles & Slater (1906) for the boundary between their *Rhynchonella* Flags and *Chonetes* Flags. The base has therefore been taken at the base of the bed above a persistent slump band (the " Concretion-Band " of Elles & Slater), which, as mentioned on page 120, can be seen at several localities in the district.

As shown in the section (Text-fig. 6) the base of the Upper Whitcliffe Beds is about 7 ft. 6 in. above the bottom of the quarry face. The slump band (F) is here about 7 in. thick. The calcareous siltstones below it are interrupted by two prominent shaly bands, whose positions are shown on the diagram. The upper one (D) is 2 to 3 in. thick and the lower (B) 2 to 6 in.

Another slump band is present in this quarry about 11 ft. above the base of the Upper Whitcliffe Beds. This is seen also in Clive Cottages Quarry (see p. 126), though it is less persistent there than the lower band. At the standard locality the upper slump band is set within strata which show the lithology of the Upper Whitcliffe Beds. If a line were to be attempted here between the two lithological types it would approximate to the position of the lower slump band.

Selected Localities

Locality 52 : see Section IV (d) page 134
Locality 54 : see Section IV (d) page 134
Locality 56 : see Section IV (d) page 135 (uppermost Upper Whitcliffe Beds with *Howellella elegans* common and a thin band crowded with *Craniops implicata*)

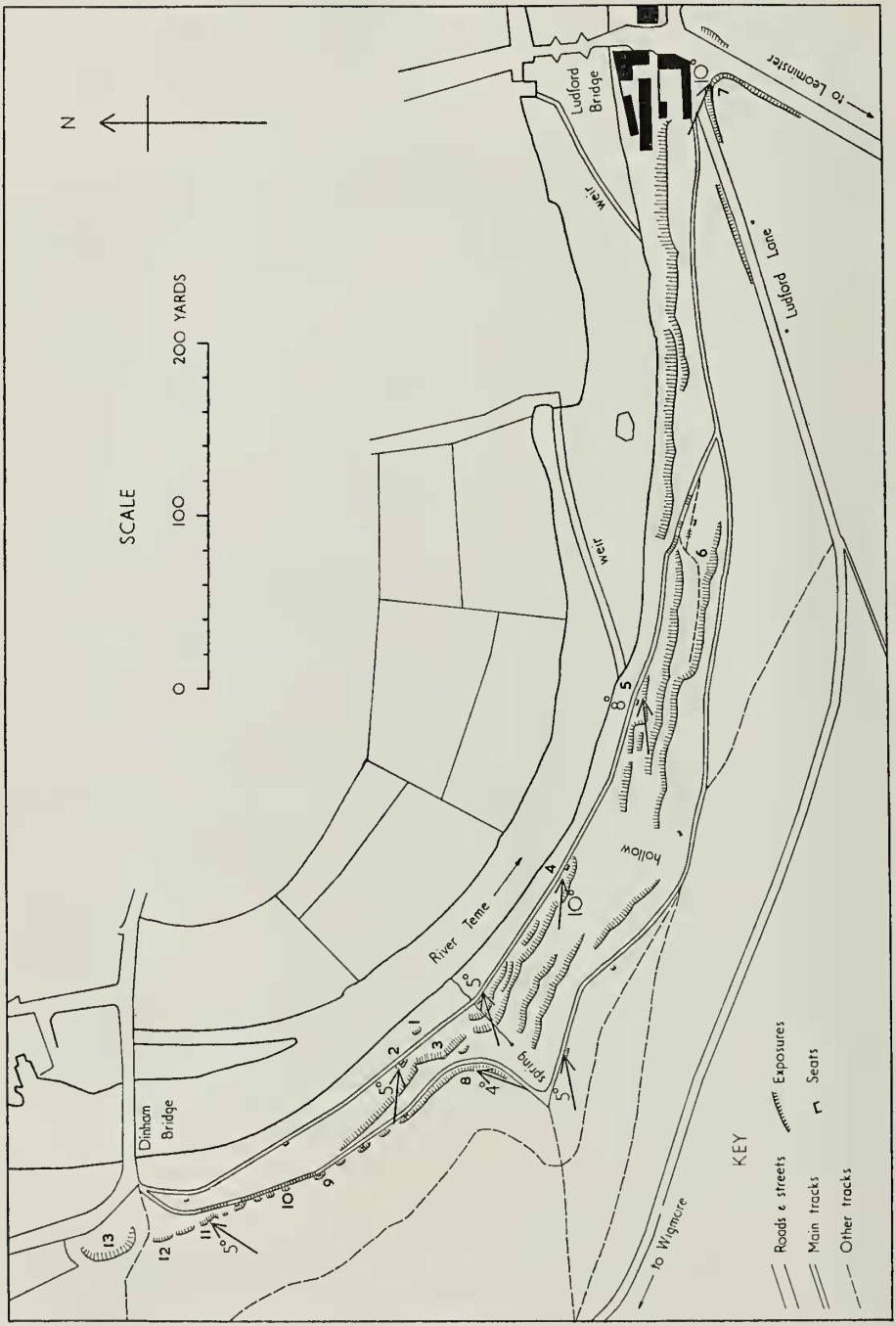


FIG. 7. Sketch-map of the Whitcliffe showing localities described in Section IV (a), pp. 125–126.

Locality 214 : see Appendix 1 page 168
Locality 255 : see Appendix 1 page 169
Locality 220 : see Appendix 1 page 168

(l) *Ludlow Bone Bed*

The Downtonian rocks of the Ludlow district were described in detail by Elles & Slater (1906). No additional description of their lithology and fauna is given here, though sections in these rocks are referred to in the accounts of the Whitcliffe (p. 126) and Downton Gorge (p 135).

Following White (1950), the present writers have taken the base of the Ludlow Bone Bed as marking the base of the Downtonian Stage and hence of the Lower Old Red Sandstone Series. For the full and precise delimitation of the Whitcliffian Stage (and the Upper Whitcliffe Beds) a standard section for the base of the Downtonian is required. The opportunity is taken to define this standard section and a description of the locality is given in Section VI, p. 146.

Other localities at which the Ludlow Bone Bed (i.e. the base of the Downtonian) may be seen are as follows :

Locality 57 : see Section IV (d) page 135
Locality 137 : see Appendix 1 page 165 (uppermost Whitcliffe Beds, Ludlow Bone Bed, and, 2 ft. 6 in. higher, Downton Bone Bed with associated *Platyschisma helicites* (J. de C. Sowerby))

IV. DETAILED DESCRIPTIONS OF IMPORTANT AREAS AND SECTIONS

(a) *Whitcliffe*

The principal exposures on the Whitcliffe are shown in Text-fig. 7. The geological lines have been omitted to avoid confusion.

Along the riverside path southwards from Dinham Bridge, the main axis of the Ludlow Anticline is crossed before the first exposures occur. At locality (1) (50747428) there is a small outcrop of Lower Leintwardine Beds, the lowest stratigraphical division represented on the Whitcliffe although Elles & Slater (1906 : 202) mapped these strata as Aymestry Limestone, with *Conchidium knighti* and *Strophonella euglypha*. Behind the seat at (2) (50717429) the Lower Leintwardine Beds contain *Atrypa reticularis, Camarotoechia nucula, Dayia navicula, Isorthis orbicularis, Leptaena rhomboidalis, Shaleria ornatella* and *Monograptus leintwardinensis* (all fairly common). On the main cliff at (3) the Upper Leintwardine Beds are fully exposed and these standard sections for the base of this division and for the base of the Whitcliffian stage are fully described on pp. 117, 145. Bands with *Chonetoidea grayi, Calymene neointermedia* and *Encrinurus* sp. occur ; the rest of the fauna is similar to that of the Lower Leintwardine Beds except that *Chonetes lepisma* is less common and *Protochonetes ludloviensis* and *Salopina lunata* are more common. These beds descend to the track beyond the spring and are last exposed in this riverside section at locality (4) (50827421). At (5) (50907417) the more thickly and irregularly bedded Lower Whitcliffe Beds occur, with *Camarotoechia nucula, Protochonetes ludloviensis, Salopina lunata, Fuchsella amygdalina, Michelinoceras imbricatum* and *Serpulites longissimus* as the commonest fossils. The rock steps are formed by massive beds

of the same division and in the Whitcliffe Quarry behind locality (6) (50967414) the base of the Upper Whitcliffe Beds has been defined at the top of a conspicuous and persistent slump band (see p. 123 and Text-fig. 6). The Upper Whitcliffe Beds are more fossiliferous than the lower division, and *Protochonetes ludloviensis* and *Salopina lunata* are relatively more common. This applies particularly to the uppermost beds which can be examined at the junction of " Ludford Lane " (i.e. the Whitcliffe road leading to Wigmore), and the road to Leominster (locality (7) (51237413)). This is the well-known outcrop of the Ludlow Bone Bed and the sequence here is referred to on p. 146.

Returning to Dinham Bridge by the track along the top of the Whitcliffe the first important exposure is at (8) (50717425) where Lower Whitcliffe Beds are seen. They are not very fossiliferous but *Camarotoechia nucula*, *Protochonetes ludloviensis* and *Salopina lunata* can easily be found. Further down the path and near the base of this same division a specimen of *Calymene* has been found, associated with *Camarotoechia nucula*, *Protochonetes ludloviensis*, *Fuchsella amygdalina*, *Bucanopsis expansus* and *Serpulites longissimus*. Lower Whitcliffe Beds still occur at (9) but the next small outcrop down the path (locality (10)) is of Upper Leintwardine Beds with *Shaleria ornatella* common. The change in lithology from the thickly and irregularly bedded Lower Whitcliffe Beds to the honeycombed, more thinly bedded Upper Leintwardine Beds is striking. At (11) (50627440) the lowest beds of the exposure are Lower Leintwardine Beds with *Dayia navicula* and *Chonetes lepisma* more frequent, but 5 ft. above the base *Calymene neointermedia*, *Encrinurus* sp. and *Chonetoidea grayi* appear, indicating the Upper Leintwardine Beds. The authors have, however, failed to find an undoubted specimen of *Neobeyrichia lauensis*, the truly diagnostic fossil for this division, anywhere on the Whitcliffe. A small fault separates this exposure from locality (12) which is of downthrown Lower Whitcliffe Beds. These also occur in the small quarry at (13) (50627445) but are best studied at Clive Cottages Quarry (50517458) which is just off the sketch map to the north. In this large quarry the slump band at the top of the Lower Whitcliffe Beds is displayed, succeeded by a considerable thickness of Upper Whitcliffe Beds, including some less persistent slump structures.

Elles & Slater (1906 : 202) appear to have mapped the honeycombed and calcareous Leintwardine Beds as the Aymestry Limestone, in spite of the frequent occurrence of *Dayia navicula* and the absence of corals, *Strophonella funiculata* and (although not according to Elles & Slater) *Conchidium knighti* and *Strophonella euglypha*. The basal Lower Whitcliffe Beds contain *Dayia navicula* and these strata seem to have been misidentified as the Mocktree Shales, but they lack all the other characteristic elements of the *Dayia navicula* fauna (e.g. *Atrypa reticularis*, *Chonetes lepisma*, *Isorthis orbicularis*, *Leptaena rhomboidalis*, *Shaleria ornatella*, *Sphaerirhynchia wilsoni* and *Monograptus leintwardinensis*).

(b) *Wigmore Road*

This section (see Text-fig. 8) permits the ascending sequence from Wenlock Limestone to the Whitcliffe Beds to be studied along an easily accessible route.

From a viewpoint on the road (456714) just over a mile to the south-west of

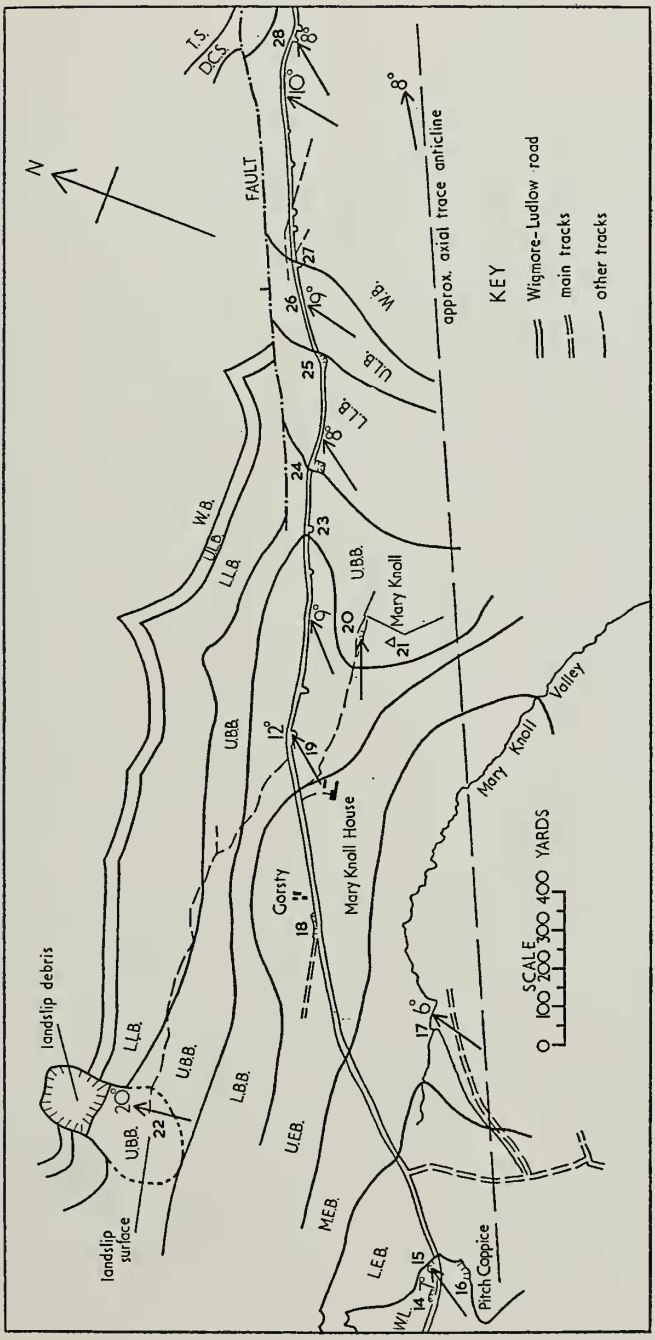


FIG. 8. Sketch-map showing localities near the Wigmore road as described in Section V (b), pp. 126–130.

Pitch Coppice, the topographic expression of the successive beds can be clearly seen. The route from this point via Pitch Coppice, along the Wigmore Road to Whitcliffe, provides a traverse almost along the anticlinal axis.

Wenlock Shales can be seen in the stream along the south side of the road, for example at (46257220), and the succeeding Wenlock Limestone is exposed in two roadside quarries at locality (14) (47167301) and locality (15) (47227304) where the change from the lower flaggy limestone to the upper nodular limestone can be noted. Fossils are scarce, but include *Atrypa reticularis, Rhipidomella hybrida, Eospirifer radiatus* and *Sowerbyella* sp., as well as reddened tubular bryozoa.

In the wood immediately opposite locality (15) is a third Wenlock Limestone exposure, locality (16) (47267301), which shows the junction with the overlying Lower Elton Beds. This is a standard locality and is described in detail on pp. 139–141. Locality (17) comprises a number of small exposures in the stream (47777324) at which fossiliferous Middle Elton Beds can be examined. *Chonetoidea grayi, Dalmanites myops* and small orthoconic nautiloids are present, but graptolites of the *Monograptus nilssoni-M. scanicus* assemblage are difficult to find.

Upper Elton Beds are well exposed at the entrance to Gorsty Farm, locality (18) (47897357) and along the adjacent level Forestry Commission track. Good specimens of *Monograptus tumescens* are common here. *Brachyprion* sp. nov., *Slava interrupta* and *Lingula* sp. may also be seen. Further along the road is locality (19) (48287377), a small overgrown quarry on the south side of the road which exposes the more calcareous Lower Bringewood Beds. Fossils are not very abundant, but brachiopods rather than graptolites are likely to be found. In particular, *Brachyprion* sp. nov., which is common, *Shaleria* sp. nov., *Gypidula lata, Leptaena rhomboidalis, Strophonella filosa, Chonetes lepisma* and *Lingula lewisi*. From a field gate immediately east of Mary Knoll House, a track leads to locality (20) (48557369), a disused quarry at the north end of Mary Knoll, which exposes about 12 ft. of Upper Bringewood Beds yielding their characteristic fauna including *Conchidium knighti, Leptaena rhomboidalis, Atrypa reticularis, Strophonella euglypha, Gypidula lata, Favosites* and *Poleumita globosa*.

The Forestry Commission track which starts immediately opposite locality (19) leads westwards to the large landslip scar, locality (22) (47337382), which provides an excellent and extensive exposure of one bedding plane in the Upper Bringewood Beds. The orientation and distribution of characteristic fossils such as *Strophonella euglypha, Atrypa reticularis, Gypidula lata, Isorthis orbicularis* and *Favosites* can be studied on this surface. The landslip, which occurred in 1947, involved about 11 ft. of flaggy limestones and flaggy calcareous siltstones which moved on a thin seam of shale, no doubt as a result of the near coincidence of dip and ground slope.

Further down the Wigmore Road from locality (19), a series of roadside exposures occurs on the south side. At the first of note, locality (23) (48747389), fossiliferous Upper Bringewood Beds yielding *Conchidium knighti* and associated fauna can be seen again. Slightly higher beds in the largest quarry, locality (24) (48887392), have previously been regarded as Aymestry Limestone, but their fauna is undoubtedly that of the Lower Leintwardine Beds and the misidentification serves to emphasize how in this eastern part of the area the middle Ludlovian calcareous

phase persists into the Leintwardine Beds. Some 30 ft. of beds are exposed in this quarry. The lowest 4 ft. are tough, blue grey limestone and calcareous siltstone with a prominent band of *Atrypa reticularis* at the top. The succeeding 10 ft. of massive calcareous siltstone with nodules of limestone weathers to a honeycomb surface and yields *Isorthis orbicularis, Atrypa reticularis* and *Chonetes lepisma.* Higher strata are poorly bedded and lack nodules. *Isorthis orbicularis* becomes more common and in the highest beds, which can also be seen on the roadside to the north-east, this brachiopod is very common and associated with *Chonetes lepisma, Sphaerirhynchia wilsoni, Leptostrophia filosa* and rare crinoid columnals. Although *Dayia navicula* is not seen, the apparent absence of *Leptaena rhomboidalis, Conchidium knighti, Gypidula, Strophonella euglypha* and corals, indicate an age younger than that of the Upper Bringewood Beds. In the immediately succeeding beds, exposed on the roadside, *Dayia navicula* and *Fuchsella amygdalina* are found with *Isorthis orbicularis, Chonetes lepisma, Camarotoechia nucula* and *Sphaerirhynchia wilsoni*—a typical Lower Leintwardine Beds fauna. The calcareous facies here is emphasized by the rare occurrence (exceptional at this horizon) of corals.

Locality (25) (49107399) is a roadside quarry which descends below road level and reveals the higher part of the Lower Leintwardine Beds. The lowest 3 ft. of beds exposed have yielded *Monograptus leintwardinensis, Dayia navicula, Strophonella euglypha, Camarotoechia nucula, Shaleria ornatella* and *Leptaena rhomboidalis,* which are all common. In the succeeding 4 ft. of beds, *Fuchsella amygdalina* (in bands) and *Shaleria ornatella* are common, associated with *Atrypa reticularis, Isorthis orbicularis, Chonetes lepisma, Leptaena rhomboidalis,* and *Dayia navicula.* The higher and less accessible beds have yielded mainly *Shaleria ornatella* and *Dayia navicula* which are common, *Isorthis orbicularis,* and *Pteronitella retroflexa.* Above road level, the highest Lower Leintwardine Beds contain *Isorthis orbicularis, Shaleria ornatella, Chonetes lepisma, Leptaena rhomboidalis, Fuchsella amygdalina, Dayia navicula,* and *Craniops implicata.*

Upper Leintwardine Beds make the ground immediately above the quarry and can be examined in two small exposures down the road, locality (26) (49227407) and locality (27) (49307412) both of which yield the typical fauna, although not readily. At locality (26), some 8 ft. of beds are exposed. *Neobeyrichia lauensis, Shaleria ornatella, Salopina lunata, Isorthis orbicularis, Camarotoechia nucula, Protochonetes ludloviensis* and bryozoans are the commonest fossils together with *Atrypa reticularis, Encrinurus* sp., *Calymene neointermedia, Orbiculoidea rugata* and *Serpulites longissimus.*

Locality (27) has also yielded most of these species, especially *Neobeyrichia lauensis, Shaleria ornatella* and *Calymene neointermedia.*

At locality (28) (49797430) Lower Whitcliffe Beds are well exposed. The poorly bedded rubbly siltstone includes concretions up to 12 in. long. Fossils are sporadic, but *Protochonetes ludloviensis* and *Camarotoechia nucula* are common, sometimes found covering bedding planes. *Salopina lunata, Michelinoceras bullatum, Goniophora cymbaeformis, Kionoceras angulatum, Fuchsella amygdalina* and *Serpulites longissimus* have also been found here.

From this point the road crosses unexposed Whitcliffe Beds to its junction with

the main Ludlow to Leominster road, where the highest Whitcliffe Beds, Ludlow Bone Bed and Downton Castle Sandstone can be examined on the south side of the corner (see p. 146).

(c) *Mary Knoll Valley*

The lower part of the Mary Knoll valley, around Sunnyhill Cottages, displays good exposures of the Ludlovian succession from the Lower Bringewood Beds to the Lower Whitcliffe Beds inclusive. There is a Forestry Commission road up the

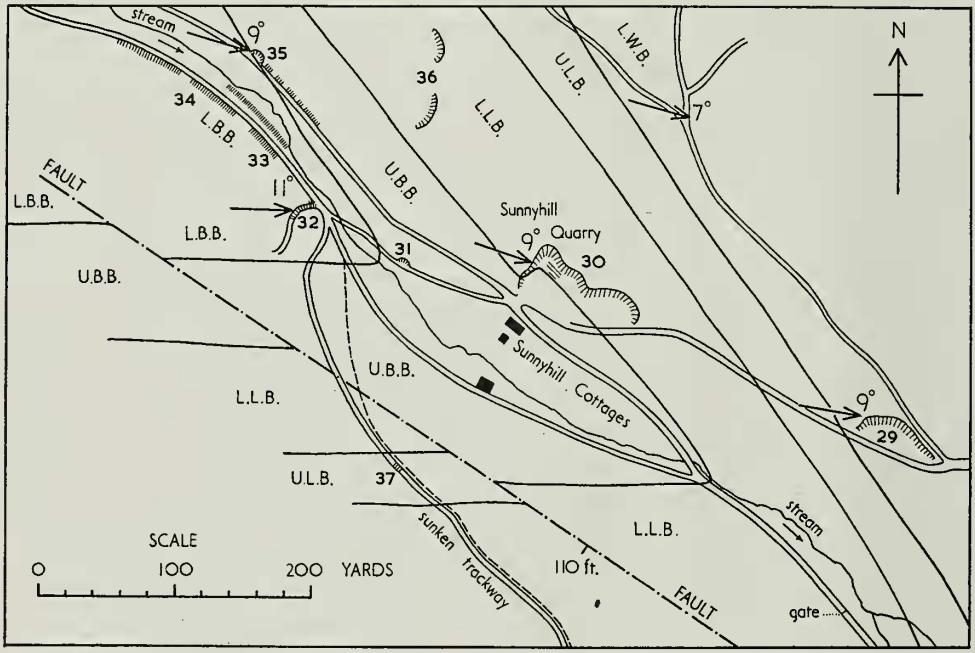


FIG. 9. Sketch-map showing localities in the Mary Knoll Valley as described in Section V (c), pp. 130–131.

western flank of the valley, from the old Leominster road at Overton to the Wigmore road near Pitch Coppice. Text-fig. 9 shows the principal exposures in the Sunnyhill area. In the quarry at locality (29) (49737244) the Lower Whitcliffe Beds are of particular interest because of the common occurrence of *Dayia navicula* ; *Protochonetes ludloviensis* is also fairly common and *Camarotoechia nucula* abundant. *Salopina lunata, Schizocrania striata, Serpulites longissimus, Michelinoceras* sp., and *Fuchsella amygdalina* also occur. These strata are again exposed alongside the track above the quarry. Descending the road to the main Sunnyhill Quarry (locality 30) : (49537255) the standard section for the base of the Leintwardinian stage can be examined (see pp. 141–145 for details). In the small quarry at locality (31) (49437255) the lowest Upper Bringewood Beds occur, being more thinly bedded and less calcareous than the higher strata of this division. A descending sequence

in Lower Bringewood Beds can be studied at localities (32), (33) and (34). At (32) (49367260) the following fossils were collected : *Atrypa reticularis, Howellella elegans, Strophonella euglypha, Strophonella funiculata* and crinoid columnals. In the roadside bank at (33) a large fauna was found : *Gypidula lata* (fairly common), *Atrypa reticularis, Brachyprion* sp. nov., *Chonetoidea grayi, Fardenia pecten, Howellella elegans, Leptaena rhomboidalis, Leptostrophia filosa, Shaleria* sp. nov., *Sphaerirhynchia wilsoni, Strophonella euglypha, Dalmanites myops, Encrinurus* sp., *Beyrichia* sp., solitary corals and *Cornulites serpularius.* At locality (34), the beds are softer and fossils less common ; *Leptaena rhomboidalis* and bryozoans were collected. About 500 yards north-westwards along the road from locality (34) the track which rises to the left leads to the standard section for the base of the Bringewoodian stage, fully described on p. 141. Opposite the commencement of this track there is a bridge over the Mary Knoll stream, and a return can be made along the road on the eastern side. There are several exposures of Upper Elton Beds in the stream (e.g. at 48927287). At locality (35) (49337268) in Text-fig. 9 there is a small quarry in the basal Upper Bringewood Beds, which are flaggy like the Lower Bringewood Beds but harder and more calcareous. Some solitary corals occur : *Atrypa reticularis* and *Strophonella euglypha* are fairly common and *Brachyprion* sp. nov., *Eospirifer radiatus, Howellella elegans, Leptaena rhomboidalis, Shaleria* sp. nov and *Strophonella funiculata* also occur. Further exposures follow in the bank of the road and the fossils include *Favosites. Conchidium knighti* has been found only in the Upper Bringewood Beds of the main Sunnyhill Quarry (locality (30)) in this area and even there it is not common. In the flanks of a broad gully above the road there are crags (36) in Lower Leintwardine Beds with Upper Leintwardine Beds at the very top. Bringewood Beds and Lower Leintwardine Beds can also be seen in the stream when the water is low.

The Sunnyhill Fault has been mapped mainly on the evidence from small exposures and debris in tree roots along the overgrown trackway ; there seems little doubt that the Upper Leintwardine Beds have been downthrown at least 100 ft. on the west side of the fault. At locality (37) (49427242) they yielded *Camarotoechia nucula, Chonetoidea grayi, Protochonetes ludloviensis, Calymene neointermedia* and *Serpulites longissimus.*

(d) *Downton Gorge and Burrington*

The gorge of the River Teme between Burrington and Downton Castle, cut by the overflow waters of the glacial lake of the Vale of Wigmore (see Dwerryhouse & Miller, 1930 : 116, 117), provides the western boundary of the district described in this paper. The area to the west of the river has been described recently by Whitaker (1962) and the following paragraphs refer to a sequence of exposures along and near its eastern bank. These exposures range from Wenlock Shales to Downtonian and most of the stratigraphical divisions are well displayed.

The area around Burrington village has long been well known for its Wenlock Shale fossils. Exposures in the sunken lanes and old quarries to the south of the village are now overgrown, but the best exposures in the Ludlow district of Wen-

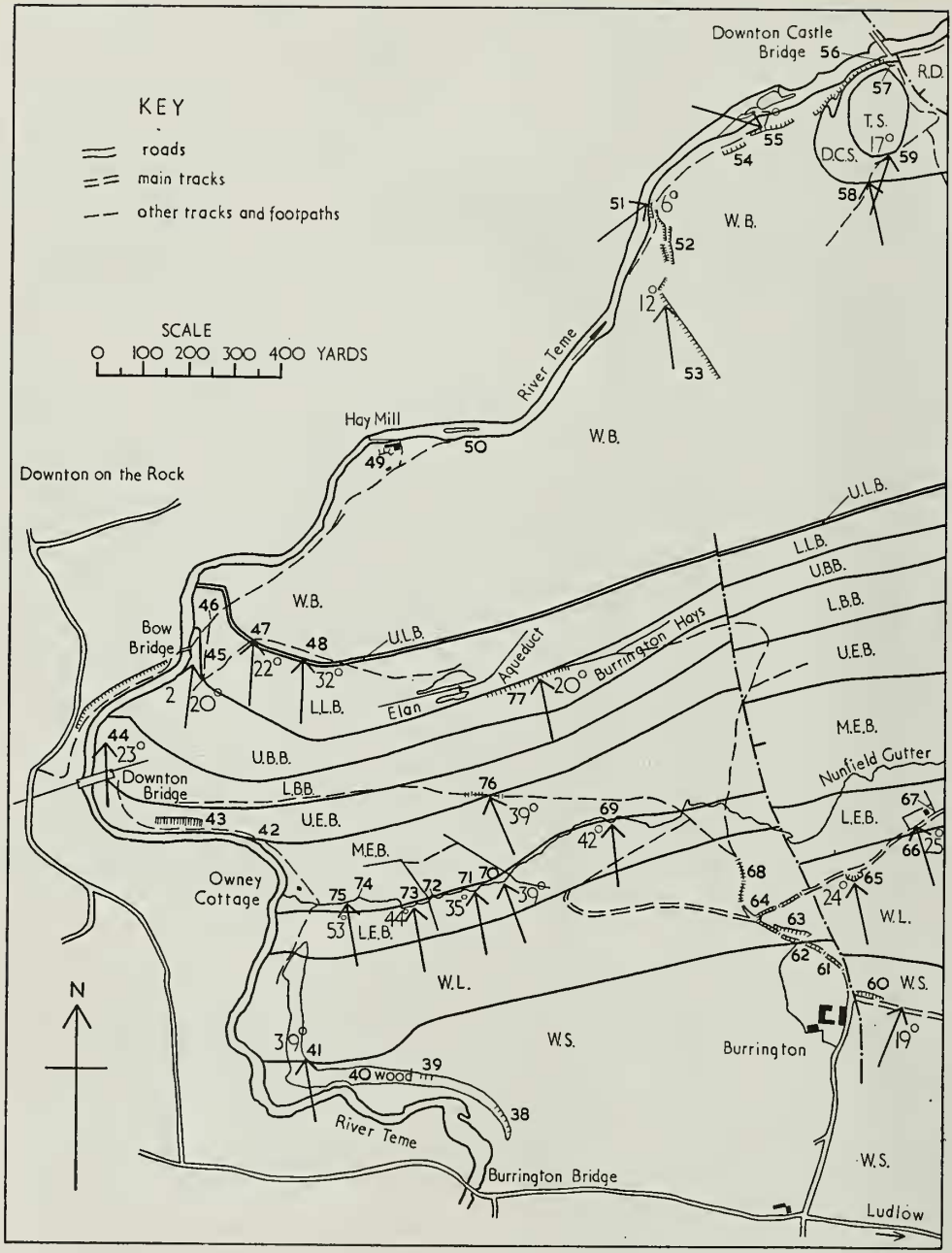


FIG. 10. Sketch-map showing localities in the Downton Gorge and Burrington area as described in Section IV (d), pp. 133–138.

lockian and lowest Ludlovian strata are still to be seen to the north and north-west of Burrington.

(1) *Downton Gorge* (see Text-fig. 10)

The eastern bank of the Teme may be reached by a field gate on the north side of the road a short distance to the east of Burrington Bridge (43607207). The steep, wooded slope of the old river cliff, rising from the alluvial flat, shows a number of small exposures of Wenlock Shales of which localities (38) and (39) are examples. The typical, light coloured, dusty weathering is seen and the fauna is an ill-preserved one of small brachiopods, orthoconic nautiloids, and the ostracod *Hemsiella maccoyana*. At locality (40) (43347227) where a track, beyond a gate, runs between river and wooded slope the bank has been cut back into Wenlock Shales. In this fresher exposure a more thickly bedded appearance and a large-scale conchoidal fracture are noticeable. *Gothograptus nassa* and *Monograptus dubius* were collected here, together with *Cyrtia exporrecta*. Flaggy limestones of the lowest Wenlock Limestone form a capping to the steep slope and are very poorly exposed at locality (41) (43277232).

Nunfield Gutter, the stream joining the Teme from the east near Owney Cottage, provides excellent exposures in the upper part of the Lower Elton Beds and the basal Middle Elton Beds, which are described later under (2).

Beyond Owney Cottage a path leads north-westwards along the river bank below an impressive wooded feature made by the Middle Elton Beds. At locality (42) (43237273) the first few small exposures just above the path are of uppermost Middle Elton Beds. These are relatively soft, shaly and thinly flaggy siltstones with graptolites (*Monograptus comis* and *M. dubius* collected), orthoconic nautiloids and common fragments of *Lingula lata*. Most of the exposures in the steep slope above the river, for example the large crags at (43) (43037280), are of typical Upper Elton Beds with their hard, smoothly bedded, flaggy siltstones. False-bedding, slump-structures, and especially crinkle markings, are all to be seen. *Monograptus tumescens* is very common but there are few other fossils.

At the top of the slope, immediately below the footpath, there are a few exposures of basal Lower Bringewood Beds. Bands of shelly fossils appear and the following were collected: *Chonetes minimus, Protochonetes ludloviensis, Howellella elegans, Shaleria* sp. nov., *Strophonella funiculata* and *Dalmanites myops*.

North of the Birmingham Corporation Elan Aqueduct at Downton Bridge there is no clear riverside path, but two small old quarries (locality (44)), one at, and one a little to the north of, the dip arrow (42897296) are easily located in a bank under trees. The typical flaggy calcareous siltstones of the Lower Bringewood Beds, with their limestone bands and lenticles, are here very fossiliferous. The fauna includes: *Chonetes minimus, Dayia navicula, Leptaena rhomboidalis, Sphaerirhynchia wilsoni, Strophonella euglypha, S. funiculata, bryozoans, Michelinoceras tenuiannulatum, Cornulites serpularius,* crinoid columnals and *Monograptus* sp.

Following the river bank north-eastwards, an extensive old quarry in Upper Bringewood Beds may be seen on the opposite side of the river. A typical " Aymestry Limestone " facies is exposed also (43067313) between the dip arrow and Bow

Bridge (locality (45)) on the eastern side of the river. There are bands of *Conchidium knighti* and *Favosites* is common. Also present are solitary corals, *Stromatopora* sp., bryozoans, *Atrypa reticularis, Brachyprion* sp. nov., *Isorthis orbicularis, Leptaena rhomboidalis, Sphaerirhynchia wilsoni, Strophonella euglypha, Cypricardinia planulata,* gastropods, *Kionoceras angulatum* and crinoid columnals.

Lower Leintwardine Beds are not well exposed in this section but at locality (46) (43117320) in the field below the track from Bow Bridge and under a tree a small exposure shows some of the fossils typical of the division. The following were collected here : *Camarotoechia nucula, Chonetes lepismus, Isorthis orbicularis, Dayia navicula, Sphaerirhynchia wilsoni, Lingula* sp., bryozoans, *Slava interrupta, Calymene* sp. and graptolite fragments.

A rising track leads southwards up the steep slope from the main track near locality (46) and branches north-eastwards to locality (47) (43197316). Here the Upper Leintwardine Beds, as is characteristic in the western part of the district, are indicated by thin biscuity bands with *Chonetoidea grayi* and *Neobeyrichia lauensis,* which can be located in poor exposures in the trackside just west of the bend. A better exposure (locality (48)) is a small old quarry (43297312) in the bracken covered ground to the south of the track. Here the uppermost 3 ft. of strata have yielded *Chonetoidea grayi* and *Neobeyrichia lauensis.*

Returning to the river bank, a clear track leads north-eastwards to Hay Mill, where an old quarry, locality (49) (43457352), shows typical Lower Whitcliffe Beds with their irregular, thickly flaggy to massive bedding and comparatively sparse fauna. The steepest and most impressive part of Downton Gorge coincides with the outcrop of the Lower Whitcliffe Beds and can be followed by a rocky pathway close to the eastern bank of the river. Typical Lower Whitcliffe Beds are exposed (locality (50)) along this pathway, though much of the material is loose. Here a representative Lower Whitcliffe fauna includes *Camarotoechia nucula* and *Fuchsella amygdalina* (both common), *Serpulites longissimus* and *Michelinoceras imbricatum* (both fairly common), together with *Protochonetes ludloviensis, Michelinoceras bullatum* and *Michelinoceras ibex.* At locality (51) (43987400) is a river cliff reached by an old walled tunnel, where the typically massive bedding of the Lower Whitcliffe Beds is seen again. Here is the approximate place at which the axis of the Downton Syncline crosses the river (see Whitaker, 1962) and the effect of the north-easterly plunge is apparent. Higher above the river the quarried crags (locality (52) (44027390)) are of more thinly bedded, somewhat yellowish weathered, Upper Whitcliffe Beds with their characteristic and common fauna. This includes especially *Camarotoechia nucula, Protochonetes ludloviensis* and *Salopina lunata,* together with the ostracod *Beyrichia kloedeni* var. *torosa.* If the long line of old quarries is followed south-eastwards away from the river the succession is descended again. At the south-eastern end (locality (53) (44107367)) may be seen the group of slump structures described in detail by Whitaker (1962) from a locality on the opposite side of the river and marking the top of the Lower Whitcliffe Beds. Further north-eastwards the riverside path passes old quarries (localities (54) and (55)) in fossiliferous Upper Whitcliffe Beds, which show an east-south-easterly dip representing the north-western limb of the Downton Syncline.

At locality (56) (44427425) where the path nears Downton Castle Bridge the uppermost Whitcliffe Beds are exposed in a small "cliff" above the path. These are the "*Spirifer elevata* shales" of Elles & Slater (1906 : 208) and this small brachiopod, now renamed *Howellella elegans*, is common. As these authors noted, there is also a thin "biscuity" band (actually approximately 8 ft. below the Ludlow Bone Bed, see locality (57)) containing abundant casts of *Craniops implicata*. A similar band is to be found in certain other Welsh Borderland areas in the uppermost part of the Ludlovian (Holland, 1962). The fauna collected from this prolific locality is as follows : bryozoans, *Camarotoechia nucula*, *Protochonetes ludloviensis* (both very common), *Craniops implicata*, *Howellella elegans*, *Lingula* sp., *Salopina lunata* (very common), *Fuchsella amygdalina*, *Goniophora cymbaeformis*, *Modiolopsis complanata*, *Pteronitella retroflexa*, *Pterinea* sp., *Loxonema* sp., *Michelinoceras imbricatum*, *Cornulites serpularius*, *Serpulites longissimus* and *Beyrichia kloedeni* var. *torosa*.

On the south-west side of the main track leading from Downton Castle Bridge an old quarry, locality (57) (44497427), shows the lowest Downtonian immediately succeeding the Whitcliffe Beds which are exposed round the corner at locality (56). The Ludlow Bone Bed is found in slightly disturbed ground at the north-western end of the quarry and about 4 ft. above present road level. About 2 ft. higher, still in the slightly disturbed bank, are *Platyschisma helicites* beds with some bony material (Downton Bone Bed). Above, and exposed in the main part of the old quarry, is typical Downton Castle Sandstone. This whole section was described by Elles & Slater (1906 : 208, 209). Within the Downton Castle Sandstone 4 ft. of massive yellowish siltstones are succeeded by a foot and a half of carbonaceous siltstones, and these in turn by some 7 ft. of laminated, false bedded, yellowish siltstones.

As shown in Text-fig. 10 a fault runs south-eastwards parallel with the track. Beyond this and along the riverside path there are exposures of Red Downtonian rocks, red weathering, greenish siltstones and micaceous sandstones, together with some red "marls". These beds are better and more typically displayed in the stream section running north-north-westwards through a wood towards the Teme at 44747442, about 300 yards from Downton Castle Bridge.

Further exposures of Downtonian strata, including the Temeside Shales, may be seen by following the track south-eastwards from the bridge and taking the branch south-westwards which leads into a large field on the dip slope. At locality (58) (44427402), some 60 yards beyond a gate, fossiliferous Upper Whitcliffe Beds, poorly exposed in the track surface, are succeeded north-eastwards by basal Downtonian beds. Specimens of the Downton Bone Bed, with its associated *Platyschisma helicites* and *Modiolopsis complanata* (J. de C. Sowerby) were collected here. Locality (59) (44497409), further to the north-east, shows bedding planes of Downton Castle Sandstone in the track below the gate. On the north side of the exposure, at the eastern end, typical blocky greenish siltstones of the Temeside Shales are seen in the bank, overlying the Downton Castle Sandstone.

(2) *Burrington*

Near Burrington Farm (44357240), Wenlock Shales are exposed by the lane leading

eastwards (locality (60)), as well as in the steep bank on the eastern side of the main lane leading northwards (locality (61)). Limestone ribs and nodules are still relatively scarce and the lithology is typical of the Wenlock Shales (see p. 103). There is calcite veining hereabouts associated with the fault shown on the sketch-map (Text-fig. 10). The rather fragmentary small brachiopods here include *Dicoelosia biloba*. Other fossils collected are orthoconic nautiloids, *Dalmanites myops* and *Monograptus vulgaris*.

At locality (62) (44257253) opposite a field boundary the base of the Wenlock Limestone is marked by a sudden increase in ribs of flaggy limestone, which above this locality alternate persistently with the shales. Above the boundary and round the bend (locality (64) (44177257)) the lane surface shows more or less continuous exposures in the alternating flaggy limestones and shales, giving the effect of a series of short stone steps. This lower flaggy part of the Wenlock Limestone is seen also in an old quarry, locality (63) (44257255), where the flaggy limestones stand out conspicuously from the face or are picked out by lichen. These beds are very poorly fossiliferous with only a few brachiopod and graptolite fragments.

Further north-eastwards the lane crosses a fault and beyond this at locality (65) an old quarry (44377266) shows the upper nodular part of the Wenlock Limestone. The fauna is still sparse but includes the following: *Stromatopora carteri*, *Atrypa reticularis*, *Leptaena rhomboidalis*, *Resserella elegantula*, *Strophonella euglypha*, *Calmene* sp., *Proetus* sp., *Hemsiella maccoyana* and crinoid columnals.

Continuing along the lane, a small exposure (44507277) under the hedge before the barn (locality (66)) shows the blocky, irregularly bedded Lower Elton Beds with their characteristic greenish colour and white shell fragments. There are hard limestone bands and nodules. The fauna includes *Camarotoechia nucula*, "*Dalmanella*" sp., *Lingula* sp., *Resserella elegantula*, *Calymene* sp., crinoid columnals and numerous brachiopod fragments. The Lower Elton Beds are exposed again at locality (67) (44537278), where a small stream emerges northwards from under the lane.

From the bend in the lane at locality (64), already referred to, a track branches northwards. At first (68) (44147263) there are exposures of the flaggy lower part of the Wenlock Limestone but down the track these are followed by nodular limestones. From here the stream section along Nunfield Gutter is easily reached and can be followed to the Teme at Owney Cottage. Locality (69) (43897278) is the standard section for the base of the Middle Elton Beds and the detailed faunal and lithological changes across this boundary are described in detail for this locality on p. 107. Further westwards the stream meanders along the boundary and there are numerous other exposures, the best of which are indicated on the map. Localities (70), (71) and (73) are of typical Lower Elton Beds while the better bedded Middle Elton Beds are seen at localities (72), (74) and (75).

The track north-westwards from locality (68) crosses Nunfield Gutter (44027279) and ascends obliquely the scarp slope of Middle and Upper Elton Beds. The standard section for the base of the Upper Elton Beds (locality (76) (43677283)) is along this track and is described in detail on pp. 110–111.

Finally, from locality (68) another branch of the track runs northwards and can

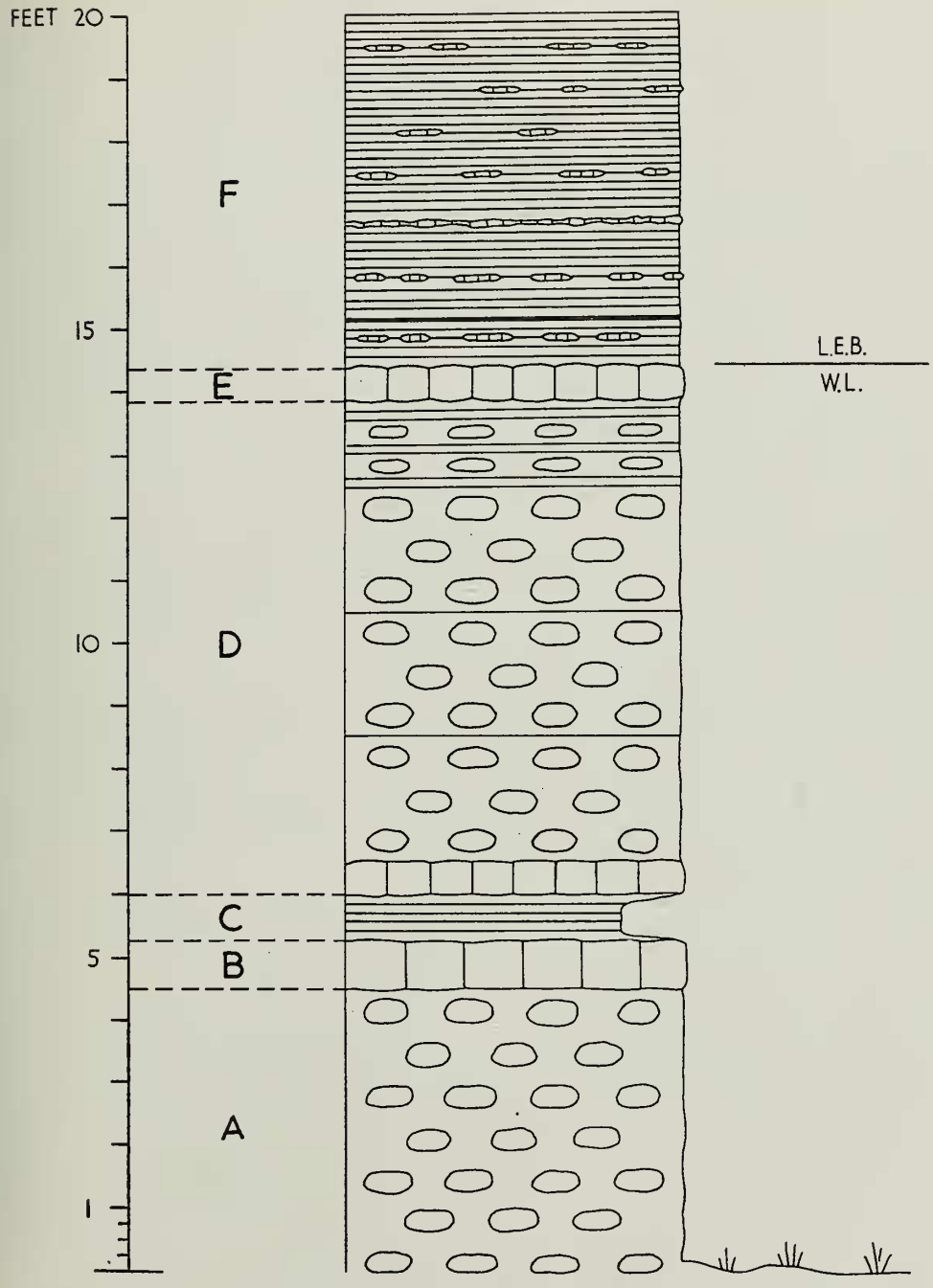


FIG. 11. Diagrammatic section showing the position of the boundary between the Wenlockian and Ludlovian Series in the quarry at Pitch Coppice (for explanation see pp. 139–141).

be followed as shown on the map to the steep wooded scarp of Burrington Hays, where a long old quarry (locality (77) (43757307) shows Upper Bringewood Beds succeeded by Lower Leintwardine Beds. The Upper Bringewood Beds are somewhat nodular, irregularly bedded limestones with the diagnostic *Conchidium knighti*. Also present are: *Atrypa reticularis*, *Dayia navicula*, *Leptaena rhomboidalis*, *Sphaerirhynchia wilsoni*, bryozoa and crinoid columnals. These limestones are succeeded sharply (contrast the standard section at Sunnyhill Quarry, locality (30), pp. 141–145) by about 9 ft. of Lower Leintwardine Beds, which are relatively soft, well bedded, thinly flaggy and shaly, calcareous siltstones. A rich brachiopod fauna includes *Atrypa reticularis*, *Camarotoechia nucula*, *Chonetes lepisma*, *Dayia navicula* (very common in bands), *Isorthis orbicularis*, *Lingula lata*, and *Sphaerirhynchia wilsoni*, together with bryozoans and *Fuchsella amygdalina*. The absence of *Conchidium knighti* and abundance of *Chonetes lepisma* and *Dayia navicula* are noteworthy, as is the appearance of *Fuchsella amygdalina*. There are thin rottenstone bands crowded with *Dayia navicula*.

V. STRUCTURE

The regional trend of the south-easterly dipping Silurian rocks from Much Wenlock through Craven Arms is interrupted by the Ludlow Anticline and the line of faulting to the south of it. This anomalous fold, like the Brecon Anticlinal which breaks the regional pattern further to the south, may well be related to important fracturing within the Pre-Cambrian basement.

The Ludlow Anticline plunges to the east-north-east at about 5 degrees and is asymmetrical with a steeper northern limb. Within the northern limb dips of 30 to 40 degrees occur to the west near Downton Gorge, while further east the dip falls to 10 to 20 degrees. The dip on the southern limb is about 10 degrees. The approximate line of the " axis " of the anticline is shown in the sketch-map of the Wigmore Road (Text-fig. 8) and is referred to in the detailed description of the Whitcliffe on p. 125.

The complementary Downton Syncline to the north-west has been described by Whitaker (1962). Its axis lies mainly to the west of the River Teme, but at the two bends to the north of Bow Bridge and near Hay Mill and along the reach above Downton Castle Bridge it lies just to the east of the river.

Faulting in the Ludlow district is in two main directions: west-south-west to east-north-east and north-west to south-east, that is, parallel and approximately perpendicular to the fold axis. The field evidence is inadequate to suggest the type of faulting.

Three more or less parallel small faults to the north and east of Burrington (see Map) affect the outcrop and topographical expression of the Wenlock Limestone. A fourth, at right angles to these and north of them, is responsible for a shift in the main Ludlovian scarp feature, causing a deep oblique valley below Burrington Hays. On the opposite, south-eastern side of the anticlinal axis two small faults near Aston again affect the Wenlock Limestone.

Of greater magnitude are the two faults along the northern margin of the district,

which in places separate the Ludlovian and Downtonian. The western fault which crosses the Teme at Downton Castle Bridge combines the two fault directions already referred to. Whitaker (1962) has traced this fault north-westwards into the Leintwardine district. Near the bridge it has a north-easterly downthrow of at least 170 ft., bringing Red Downtonian against uppermost Ludlovian. About a mile to the east there is evidence that the throw has diminished. At locality 139 (see Appendix 1, p. 166), for example, the fault is seen between uppermost Ludlovian and Downton Castle Sandstone. Only 8 ft. of the latter is present under the Temeside Shales. Thus the northerly downthrow is here about 40 ft. A short distance to the east the fault dies away.

The second of the two northern boundary faults can be traced from the north of Ludlow Castle westwards for about a mile and a half parallel to the anticlinal axis, and makes a steep scarp feature. At its maximum northerly downthrow of about 270 ft., the base of the Whitcliffe Beds is in contact with the base of the Red Downtonian. On the folding map, over two miles of unfaulted boundary between Ludlovian and Downtonian connects the faults described above. This interpretation differs from that of Elles & Slater (1906), in which there is a single northern boundary fault.

Moving southwards from Ludlow (see Map), a pair of north-west to south-east faults is shown near Overton. Evidence for the longer one along the Mary Knoll valley is given on p. 131.

Finally, the three faults at the south-eastern limit of the district are but a small part of a line of faulting of regional significance which extends east-north-eastwards through Titterstone Clee Hill to the Forest of Wyre Coalfield and west-south-westwards to join the Church Stretton Disturbance near Presteigne. The southernmost fault is the important one in this group of three and has a downthrow to the north of about 200 ft.

From the evidence obtained within the Ludlow district itself it can only be said that the age of the movements which produced the Ludlow Anticline and its associated faults is post-Downtonian. Ball & Dineley (1961) have given evidence from the Clee Hills that the main form of these structures was set by post-Dittonian pre-Farlovian movements, but that there were later movements at the end of the Farlovian and during the Carboniferous.

VI. STAGES OF THE LUDLOVIAN

As explained in Section II, the four stages into which the Ludlovian Series is here divided have been defined by means of standard sections for their bases. Detailed descriptions of these four standard sections are included in the following pages. In order to delimit the Ludlovian Series a standard section for the base of the Downtonian Stage of the Lower Old Red Sandstone Series is then described.

(a) *Base of the Eltonian Stage*

The standard section for the base of the Ludlovian Series, Eltonian Stage, and Lower Elton Beds is in the old quarry (47267301) in Pitch Coppice, on the south side of the Ludlow-Wigmore road about one mile north-east of Aston Church. The

quarry is shown on the sketch-map (Text-fig. 8, locality (16)) and a diagrammatic section of the face is given in Text-fig. 11. Nearly 15 ft. of Wenlock Limestone is capped by several feet of Lower Elton Beds. The latter are accessible at both the western and eastern ends of the quarry face and are exposed also in a bank above the north-western corner of the quarry.

The Lower Elton Beds, though rich in broken shell fragments, are poor in identifiable fossils. There is however a clear lithological change from the Wenlock Limestone below, at which the boundary is defined. The uppermost Wenlock Limestone here, as elsewhere in the district, is nodular in character and the succeeding Lower Elton Beds are typical soft, olive, shaly siltstones.

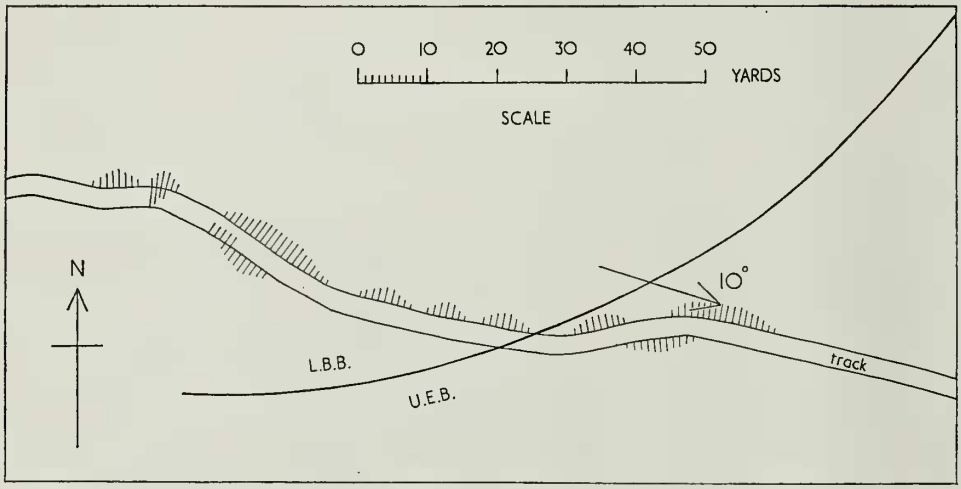


Fig. 12. Plan of the standard locality in Mary Knoll Valley for the boundary between the Eltonian and Bringewoodian Stages (for explanation see opposite).

Details of the lithological changes near the boundary as shown in Text-fig. 11 are as follows : the lower part of the quarry face (A) is of massive, nodular, grey limestone capped by (B) a hard ledge of limestone 8 to 10 in. thick. Above this are 8 to 9 in. of shales (C) (similar to the Wenlock Shales) which have been weathered back to a conspicuous hollow along the face. Above this are nodular limestones (D) almost 8 ft. thick with some thin shaly partings especially towards the top. Completing the Wenlock Limestone is a cap (E) of 5 to 7 in. of hard limestone. The succeeding Eltonian (F) is of soft, olive, calcareous shaly siltstones with white shell fragments, broken by irregular thin bands and lenses of hard limestone. There is a thin clay band 9 in. from the base.

From the Wenlock Limestone in this quarry, the following have been recorded : *Favosites asper, Heliolites interstinctus, Thecia grayana,* solitary coral, bryozoans, *Atrypa reticularis, Gypidula galeata, Leptaena rhomboidalis, Resserella elegantula, Sphaerirhynchia wilsoni, Strophonella euglypha, Poleumita discors, Lituites ibex,* crinoid columnals, *Dalmanites myops, Hemsiella maccoyana* and *Primitia* sp.

Apart from their abundant shell fragments, the Lower Elton Beds have yielded *Atrypa reticularis, Chonetes minimus, Leptaena rhomboidalis, Resserella elegantula, Calymene* sp., bryozoans, crinoid columnals and ostracod fragments.

The question of the graptolite zones about the Wenlockian-Ludlovian boundary (Das Gupta, 1932; Pocock, Wedd & Robertson, 1938; Whittard, 1952) remains difficult in that the position of the base of the *Monograptus vulgaris* Zone in relation to the Wenlock Limestone is not known. In the present investigation the only relevant graptolite evidence is the occurrence in the higher beds of the Wenlock Shales of *Gothograptus nassa, Monograptus dubius* and *M. vulgaris*, of which the second is the least rare. Such an assemblage is not inconsistent with either the *Cyrtograptus lundgreni* Zone or *Monograptus vulgaris* Zone but is perhaps more characteristic of the higher part of the former. The problem of the graptolite sequence in areas where the Wenlock Limestone is developed might be solved by prolonged collecting throughout the Welsh Borderland but the rarity of graptolites at this level in the shelf facies would make this a most difficult task. In any event it is desirable that at the standard locality the Wenlock Limestone should be within the Wenlockian and the Ludlovian (Eltonian) should begin above it.

(b) *Base of the Bringewoodian Stage*

The standard locality for the base of the Bringewoodian Stage is on the western slopes of the Mary Knoll Valley and is a track section (map reference 48737292 and Text-fig. 12). It is reached by following the Forestry Commission road shown on Text-fig. 9 north-westwards for a further 375 yards beyond the edge of that map until a tributary stream is crossed and two paths branch off to the left. About 150 yards along the ascending track the standard section commences. It is the standard for the base of the Lower Bringewood Beds and for the base of the Bringewoodian Stage.

The junction is not clearly defined but is perhaps most accurately described as a rapid transition in both lithology and fauna. The Upper Elton Beds are somewhat calcareous, smoothly bedded, flaggy and shaly siltstones with occasional hard flaggy limestone bands; *Monograptus tumescens* is abundant in the flaggy bands which break off in large pieces. Shelly fossils are not common apart from *Chonetes lepisma* but *Dalmanites myops* occurs. The Lower Bringewood Beds here are not yet typical but are slightly more thickly and irregularly bedded than the Upper Elton Beds, with a notable absence of the flaggy limestones. It is less easy to collect slabs of rock. These beds were probably originally more calcareous than the Upper Elton Beds but are now decalcified to a brownish colour. *Monograptus tumescens* is still fairly common in the basal beds but shelly fossils become more abundant particularly *Brachyprion* sp. nov. *Chonetes lepisma* is very common; *Dalmanites myops, Camarotoechia nucula, Dayia navicula*, bryozoans and ostracods also occur. The position of the boundary is shown on the map (Text-fig. 12).

(c) *Base of the Leintwardinian Stage*

The standard section for the base of the Leintwardinian Stage and also therefore for the base of the Lower Leintwardine Beds is on the north-west face of Sunnyhill

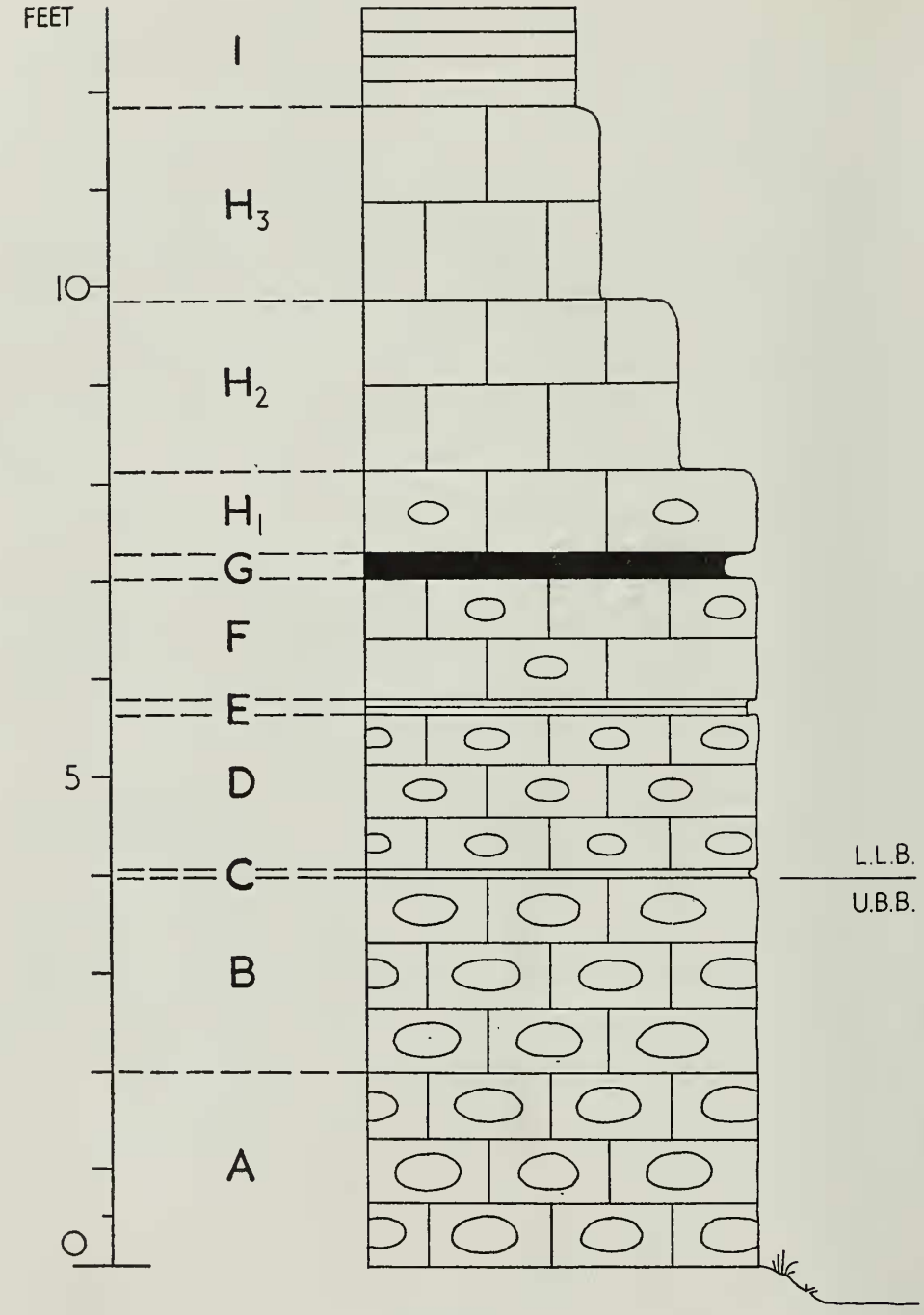


FIG. 13. Diagrammatic section showing the position of the boundary between the Bringewoodian and Leintwardinian Stages at Sunnyhill Quarry (for explanation see opposite).

Quarry (map reference 49537255, map, Text-fig. 9). A diagrammatic section across the boundary is shown in Text-fig. 13. On first examination this quarry might appear to be entirely in the Aymestry Limestone of the earlier classification (and therefore probably in the Upper Bringewood Beds of this classification). The fauna of most of the strata, however, is unmistakably that of the Mocktree Shales (i.e. Lower Leintwardine Beds of this classification). In this eastern part of the area the calcareous phase in the middle of the Ludlovian persists into the Leintwardinian Stage. The quarry mainly shows thinly bedded calcareous siltstones but the clean vertical joint faces encourage the illusion of massive limestones. If the Geological Survey usage of the term Aymestry Limestone as a rock-stratigraphical unit is followed then this quarry might be mapped as Aymestry Limestone, but in the *Dayia navicula* Zone not the *Conchidium knighti* Zone of Elles & Slater (1906). The lowest beds are seen in the west close to the road and consist of 4 ft. of nodular limestones and calcareous siltstones with uneven partings. In the lower 2 ft. (A in Text-fig. 13) such typical Upper Bringewood fossils as *Conchidium knighti, Strophonella euglypha, Rhabdocyclus* and small trochoid corals have been found. Of forms which range above, *Atrypa reticularis* is abundant, crinoid columnals are common and *Camarotoechia nucula, Howellella elegans, Isorthis orbicularis, Leptaena rhomboidalis* and *Sphaerirhynchia wilsoni* are present. In the upper 2 ft. (B), *Atrypa reticularis* and *Isorthis orbicularis* are the dominant fossils. Crinoid columnals are also common and *Camarotoechia nucula, Dayia navicula, Sphaerirhynchia wilsoni* and *Monograptus* sp. also occur.

Dayia navicula occurs in the Lower Bringewood Beds and the *Monograptus* is unidentifiable so that in spite of no diagnostic Bringewood fossils being found in section B it has been decided not to separate the latter from A, with which it is in lithological continuity. The boundary has therefore been taken at the base of the ¼-in. shale parting C, although the fauna in the succeeding 8 ft. is substantially similar to that in B. D consists of 19 in. of more thinly bedded nodular limestones and calcareous siltstones. E is a 2-in. wide shale band overlain by F, 15 in. of massive, somewhat nodular limestone. There succeeds a prominent 3-in. band of soft clay (G) which can be traced also between the two lowest ledges of limestone below the main face, although here the clay band is hidden by a thick growth of grass. Above, in H, there follows 4½ ft. of flaggy to massive, silty limestone, somewhat nodular especially in the lower part. Below the main face of the quarry these limestones form the two upper ledges (10 in. and 21 in.) plus 2 ft. of rock before the beds at I.

The general faunal characteristics of the 8 ft. of beds D to H inclusive are as follows: common fossils are *Atrypa reticularis, Camarotoechia nucula, Isorthis orbicularis* and crinoid columnals; also present are *Chonetes lepisma, Dayia navicula, Shaleria ornatella, Sphaerirhynchia wilsoni, Craniops implicata, Lingula lewisi, Orbiculoidea rugata, Slava interrupta* and *Beyrichia* sp. One specimen which may be a *Gypidula* was found in the top of H and pentagonal crinoid columnals occur sparsely in F and H_1. In the succeeding beds (I) there is a distinct lithological change to thinly flaggy, even shaly, calcareous siltstones with frequent curved joint surfaces; *Chonetes lepisma* and *Dayia navicula* now appear in some abundance.

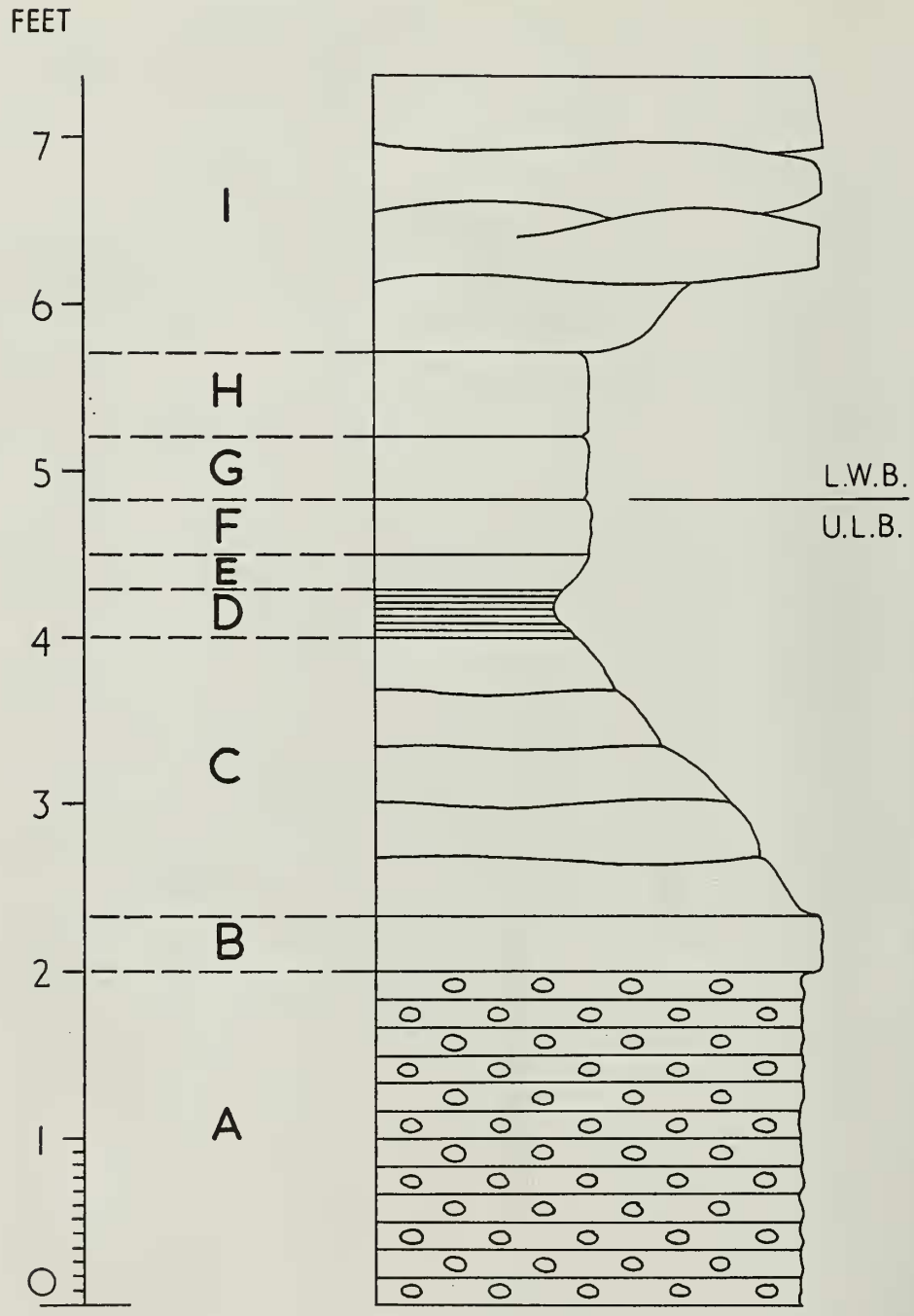


FIG. 14. Diagrammatic section showing the position of the boundary between the Leintwardinian and Whitcliffian Stages on the Whitcliffe (for explanation see opposite).

Although this change would seem to offer a suitable boundary in this particular quarry it is considered that the disappearance of the Bringewood forms is of more significance in wider correlation and therefore a more suitable criterion for a stage boundary. For this reason the shale parting C has been preferred.

(d) *Base of the Whitcliffian Stage*

The standard section for the base of the Whitcliffian Stage and for the base of the Lower Whitcliffe Beds is at locality (3) on the sketch-map of the Whitcliffe (Text-fig. 7). The map reference is 50717428 and the line Y indicates the position of the section in the sketch of the cliff (Text-fig. 4). A vertical section across the boundary is given in Text-fig. 14 and a photograph in Plate 2.

At the top of the slope rising from the river bank the cliff starts with about 5 ft. of flaggy calcareous siltstones, conspicuously honeycombed, of which only the top 2 ft. are shown as A in the diagram (Text-fig. 14). These are clearly Upper Leintwardine Beds and contain *Atrypa reticularis*, *Camarotoechia nucula* (common), *Protochonetes ludloviensis*, *Chonetoidea grayi*, "*Dalmanella*" sp., *Leptaena rhomboidalis*, *Shaleria ornatella*, *Calymene neointermedia*, *Encrinurus* sp., proetid trilobite, *Pterinea nupera*, *Pteronitella retroflexa*, *Michelinoceras bullatum*, *Kionoceras angulatum*, *Bucanopsis expansus*, *Serpulites longissimus* and bryozoans. Bed B is an easily identifiable siltstone cap about 3–4½ in. thick (indicated by the matchbox in Plate 2) and includes a layer fairly rich in biotite flakes; fossils are not common but *Atrypa reticularis*, *Camarotoechia nucula*, *Leptaena rhomboidalis*, *Fuchsella amygdalina*, *Serpulites longissimus*, bryozoans and crinoid columnals have been found. The succeeding 20 in. of siltstones (C) are more thickly and irregularly bedded and less calcareous; lithologically they resemble the Lower Whitcliffe Beds but the fairly common occurrence of *Shaleria ornatella* and the presence of *Monograptus* cf. *leintwardinensis* indicate the Upper Leintwardine Beds. Other fossils are *Camarotoechia nucula* (large form common), *Protochonetes ludloviensis* (often small), *Dayia navicula*, *Orbiculoidea rugata*, *Salopina lunata*, *Fuchsella amygdalina*, *Pteronitella retroflexa*, *Michelinoceras bullatum*, *Bembexia lloydi*, *Serpulites longissimus* and bryozoans. Several seams of shell fragments occur. D comprises 3½ in. of shale overlain by 2–2½ in. of calcareous siltstone (E); these beds have yielded *Camarotoechia nucula*, *Protochonetes ludloviensis*, *Dayia navicula*, *Lingula lewisi*, *Fuchsella amygdalina*, *Pteronitella retroflexa*, *Kionoceras angulatum* and *Cyclonema coralli*. F is a very fossiliferous calcareous siltstone 3½ to 4 in. thick and the abundance of *Chonetoidea grayi* is taken as a definite indication of Upper Leintwardine Beds. *Shaleria ornatella* also occurs, together with *Camarotoechia nucula*, *Protochonetes ludloviensis*, *Craniops implicata*, *Dayia navicula*, *Michelinoceras* sp., *Kionoceras angulatum*, *Serpulites longissimus* and *Bythocypris* sp.

The base of the succeeding bed G, a poorly fossiliferous calcareous siltstone 4–4½ in. thick (indicated by the head of the upper hammer in Plate 2) is defined as the base of the Lower Whitcliffe Beds and of the Whitcliffian Stage. Above is a 6 in. band of shelly limestone (H) and although fossils are common, there is now no sign of the characteristic Leintwardinian fauna. *Camarotoechia nucula*, *Protochonetes*

ludloviensis and *Dayia navicula* occur most frequently. The overhanging strata in I are typical thickly and irregularly bedded siltstones of the Lower Whitcliffe Beds. *Camarotoechia nucula* (large form) and *Fuchsella amygdalina* are common; *Protochonetes ludloviensis* (often small), *Michelinoceras imbricatum* and *Bembexia lloydi* also occur.

The total thickness of the Upper Leintwardine Beds in this standard section on the Whitcliffe is 18 ft.

(e) *Base of the Downtonian Stage*

The upper limit of the Whitcliffian Stage, and therefore of the Ludlovian Series, is taken at the base of the Ludlow Bone Bed in the "Ludford Lane" section (51237413). This is shown as locality (7) on the sketch-map of the Whitcliffe (Text-fig. 7). This horizon is here *defined* as the base of the Downtonian Stage and the Lower Old Red Sandstone Series.

The Upper Whitcliffe Beds are grey, calcareous, flaggy siltstones with *Camarotoechia nucula, Protochonetes ludloviensis, Howellella elegans* and *Salopina lunata* common. Above the Ludlow Bone Bed, the siltstones of the Downton Castle Sandstone formation are somewhat coarser than those of the Upper Whitcliffe Beds. In composition they are more micaceous and less calcareous, whilst in colour, yellowish and greenish tints are more common. Faunally the formation is characterized by the occurrence of *Lingula minima* J. de C. Sowerby, *Kloedenia wilckensiana* (Jones), *Modiolopsis complanata, Platyschisma helicites*, eurypterids, plants, and fish remains in thin layers. The 3 ft. of strata above the Ludlow Bone Bed are poorly fossiliferous. Above this, and up to 6 ft. above the Bone Bed where the yellowish false-bedded sandstones begin, the fauna is well developed with several ostracod bands and common *Platyschisma helicites*.

VII. CORRELATION

(a) *Wenlockian Series*

As no faunal divisions of the shelf Wenlockian Series based on shelly fossils have yet been proposed, only a lithological correlation of the formations are possible. The Wenlock Shales of the Ludlow district are similar to those below Wenlock Edge and in the inliers of Woolhope, Malvern and May Hill. The succeeding flaggy limestones and shales are quarried; they form a fairly strong feature and have therefore been classified here as Wenlock Limestone. Only the highest 50 ft. of nodular beds, however, are sufficiently calcareous and fossiliferous to invite comparison with the so-called typical Wenlock Limestone of Wenlock Edge and Wren's Nest. As the Ludlow area is closer to the basin facies it may well be that the lower flaggy division is a more argillaceous lateral equivalent of the lower part of the Wenlock Limestone elsewhere, although lithologically these strata show some resemblance to the Tickwood Beds, the uppermost division of the Wenlock Shales in the type area.

The problem of the definition of the top of the Wenlock Limestone is discussed on pp. 140–141.

(b) *Ludlovian Series*

Various authors in recent years (Lawson, 1955 ; Walmsley, 1959 ; Holland, 1959 ; Squirrell & Tucker, 1960) have made tentative correlations between the areas they have mapped and the Ludlow district. These correlations are now reconsidered in terms of the revised classification which includes the two widespread and faunally distinctive divisions, the Lower Bringewood Beds and the Upper Leintwardine Beds, not recognized by earlier writers on the Ludlow area. The detailed reasons for the preferred correlations are not repeated from these recent papers.

In the chart (Table II), firm lines in columns 5, 6, 7, 8 and 9 indicate a fairly certain correlation with the biostratigraphical divisions at Ludlow. Firm lines in column 10 (Generalized Basin Succession) suggest a reliable correlation with the Ludlow classification in column 4. In columns 11–16 firm lines indicate a fairly certain correlation with the basin divisions of column 10. Column 17 gives the graptolite zones introduced by Wood (1900) and modified slightly by Alexander (1936). The units in columns 5 to 17 are all essentially biostratigraphical (or faunal) divisions and their correlation with the time-rock classification into stages (column 3) depends on the reliability of certain fossils as time indices. At present, no better criteria are available. Most reliance has been placed on the graptolites but as they are not common in the shelf facies and are absent altogether from the higher beds it is necessary to make cautious use of the shelly faunas (see Lawson, 1960). Certain trilobites (e.g. *Calymene neointermedia*) and ostracods (e.g. *Neobeyrichia lauensis*) have a relatively restricted range and show some independence of facies changes ; these are the most valuable of the shelly fossils for correlation. The brachiopods were more influenced by changes in the conditions of sedimentation so that even the distinctive assemblages can only be trusted within limits. As explained more fully by Lawson (1960 : 123) it is the disappearance of these successive faunas that is of most significance, although only in the British area. There are a few brachiopod species, however, which do disappear at approximately the same stratigraphical level (using graptolite zones as criteria) both within and beyond the British area (e.g. *Dicoelosia biloba, Skenidioides lewisi, Strophonella euglypha, S. funiculata*). The mollusca, corals and bryozoans, in spite of their greater dependence on environment, are helpful in correlation over short distances particularly when considered together with the more reliable fossils in the assemblages. The detailed application of these principles is seen in the papers on particular areas listed above and in a general paper on the Ludlovian rocks of the Welsh Borderland by Lawson and others (1956).

(i) *Shelf Facies*

The general characteristics of this development have recently been summarized by Lawson (1960 : 114) and will not be repeated here.

(1) *Leintwardine* (Column 5)

The succession in this area immediately west of the Ludlow district has recently been described by Whitaker (1962). There is a greater total thickness of strata and the sediments and faunas show distinct affinities with those of the basin facies. It

is therefore of particular interest to note the thick development of the shallow-water, calcareous Upper Bringewood Beds (Aymestry Limestone facies) and the presence of a marked unconformity along the lines of submarine channels eroded in Leintwardinian times.

(2) *Usk* (Column 6)

It is now proposed that the names of the biostratigraphical divisions at Ludlow be applied to equivalent divisions in the shelf inliers. The local names need only be used where correlation is uncertain. For example, the Lower Llanbadoc Beds can now be referred to as the Upper Bringewood Beds of Usk. The rock-stratigraphical term Aymestry Limestone, which many geologists might at first prefer, can be used only for the Lower Llanbadoc Beds in the east of the inlier. To the west these strata, although still resistant enough to form a feature, are not sufficiently calcareous to justify the name limestone.

In this inlier (Walmsley, 1959) there is a complete succession of comparable thickness to that at Ludlow and correlation is straightforward apart from the Elton Beds. The Lower Elton Beds compare with the basal Lower Forest Beds and the Upper Elton Beds are perhaps indicated by the rare occurrence of *Monograptus* cf. *tumescens* in the otherwise shelly upper part of the Lower Forest Beds. The Elton Beds and the Lower Forest Beds are of similar thickness and it seems likely that the Middle Elton Beds are here represented by the middle of the Lower Forest Beds in a non-graptolitic development. The twofold division of the Whitcliffe Beds has not been recognized at Usk but the highest Ludlovian strata in the inlier are distinguished by the abundance of *Loxonema* [*Holopella*], as at Builth.

(3) *Woolhope* (Column 7)

Squirrell & Tucker (1960 : 156) correlated the Ludlovian of the Woolhope area with the old classification at Ludlow. Lower Elton Beds are recognizable in the base of the Lower Wootton Beds and the presence of *Monograptus* cf. *colonus* var. *compactus* and *M. varians* in the higher part of this division suggests a correlation with the Middle Elton Beds. Upper Elton Beds are proved by the abundance of *M. tumescens* in the Upper Wootton Beds. The predominance of shelly fossils, yet with sufficient diagnostic graptolites, in the Elton Beds of Woolhope assists in the correlation of Elton Beds at Usk and May Hill where graptolites are much rarer.

In northern Woolhope there is a complete succession of comparable thickness to that at Ludlow, but in the south of the area the series thins to 200 ft., the Upper Sleaves Oak Beds (i.e. Upper Bringewood Beds) being cut out altogether. A pebble bed occurs at the base of the Lower Bodenham Beds (i.e. Lower Leintwardine Beds) and a phosphatized fragment bed at the top of the Upper Bodenham Beds (Upper Leintwardine Beds).

(4) *Gorsley* (Column 8)

The quarries near Gorsley (Lawson, 1954) between Woolhope and May Hill, reveal that the Ludlovian rocks are reduced to a thickness of 11½ ft., comprising 7 ft. of

Lower Siltstones (i.e. Lower Leintwardine Beds) and 4½ ft. of Upper Siltstones (i.e. Whitcliffe Beds). The new Tewkesbury to Ross motorway crosses this area and has exposed (SO 67152661) strata containing *Calymene neointermedia*, *Whitfieldella canalis* and *Sphaerirhynchia wilsoni*, together with phosphatized fragments and pebbles. This fauna suggests the presence of the very highest Lower Leintwardine Beds or the basal Upper Leintwardine Beds.

(5) *May Hill* (Column 9)

The Ludlovian Series at May Hill (Lawson, 1955) has a maximum thickness of 245 ft. Lower Elton Beds are represented by the similar Lower Flaxley Beds, although the occurrence in these latter of *Monograptus uncinatus* var. *orbatus* suggests that the Middle Elton Beds may be present in part. No Upper Elton Beds occur, even in their more shelly development as seen at Woolhope. A small thickness of Upper Bringewood Beds, although not in their Aymestry Limestone facies, can be recognized in the highest Upper Flaxley Beds at Blaisdon, where they contain *Favosites* and simple corals.

The base of the Upper Leintwardine Beds may be a foot or so above the base of the Lower Longhope Beds, which have been defined on the appearance of *Calymene neointermedia*, thereby incorporating strata with *Sphaerirhynchia wilsoni*. Since the paper on May Hill was written, *Chonetoidea grayi* has been found in these Lower Longhope Beds (Upper Leintwardine Beds) at locality D in Text-fig. 2 of Lawson (1955 : 95). In some places a thin phosphatized fragment layer occurs at the base of these beds as well as at the top. The Upper Longhope Beds (Whitcliffe Beds) have not been subdivided.

(6) *Malverns*

The southern Malvern succession has been studied by Phipps (1957) but the results remain unpublished. The Elton Beds are non-graptolitic and show interesting lateral changes in their shelly fauna. The thicknesses of the Lower and Upper Bringewood Beds are complementary ; the latter division comprises thick, massive limestone only in the west of the area. The Lower Leintwardine Beds develop conglomeratic layers towards the south-west (i.e. approaching the Gorsley Axis). One specimen of *Neobeyrichia lauensis* has been found in the Upper Leintwardine Beds. The Whitcliffe Beds have not been subdivided.

(7) *Newnham*

Near Aram's Farm, west of Newnham, a small inlier (SO 680109) of Ludlovian rocks appears between the Old Red Sandstone and the Triassic. Dr. H. C. Squirrell has recognized Elton or Lower Bringewood Beds, Lower Leintwardine Beds, Upper Leintwardine Beds and possibly Lower Whitcliffe Beds.

(8) *Tites Point*

At low tide Ludlovian rocks are exposed on the eastern shore of the River Severn (SO 692048). The oldest strata appear to be Lower Leintwardine Beds with layers of

limestone conglomerate ; the fauna includes solitary corals, large *Atrypa reticularis, Camarotoechia nucula, Protochonetes ludloviensis, Dayia navicula, Isorthis orbicularis, Sphaerirhynchia wilsoni* and small *Whitfieldella canalis*. No Upper Leintwardine Beds have been recognized. The Whitcliffe Beds appear to pass upwards conformably into reddish shaly siltstone with bands of mud pellets, specimens of *Lingula* and plants. These beds may represent a brackish water phase in late Ludlovian times for along the southern belt of the Silurian sea there seems to have been a tendency for brackish water or continental conditions to develop before the end of the Ludlovian (e.g. Cardiff, Llandovery and possibly Pembrokeshire and southern Ireland).

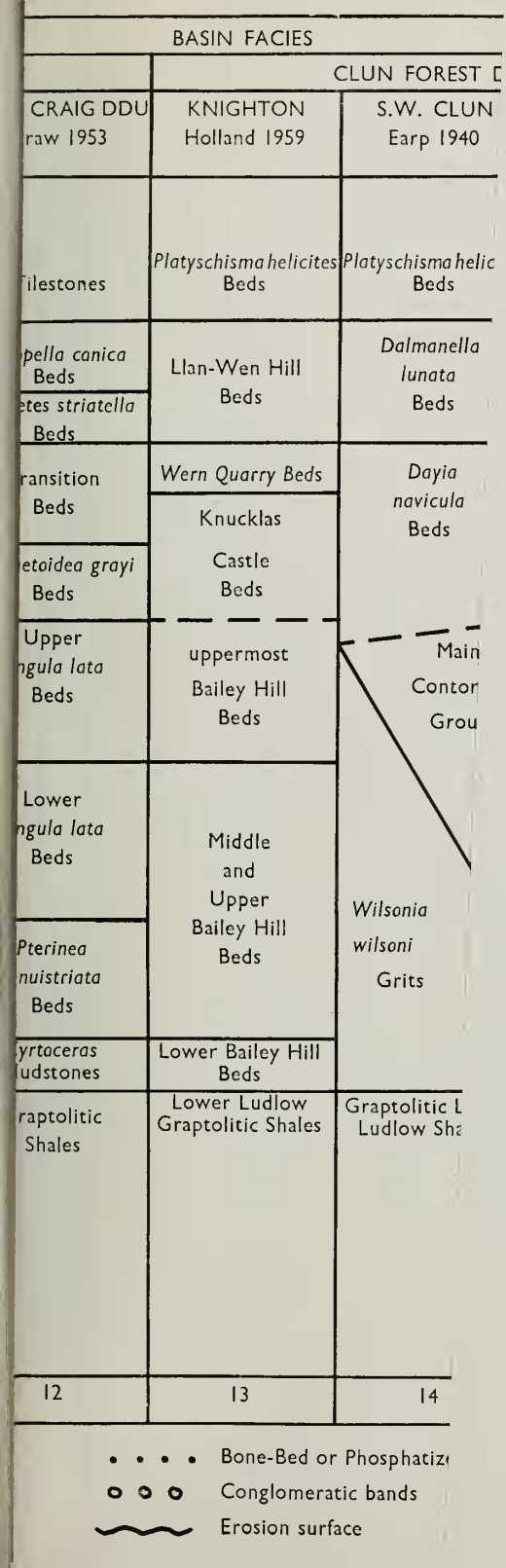
(9) *Central England*

The most complete and instructive section in the Ludlovian strata of this region is in the road section at Lye (SO 930845), described by King & Lewis (1912) but recently re-examined in order to compare it with the Ludlow succession. No Elton Beds or Lower Bringewood Beds are seen but the Upper Bringewood Beds are probably represented by the few feet of massive Sedgley Limestone still visible. The succeeding thinly bedded Sedgley Limestone (well exposed also at Beacon Hill, Sedgley, SO 919949) represents the Leintwardine Beds of the revised classification and is 35 ft. thick. The basal 8 ft. contain several calcareous pebble bands similar to those at the same stratigraphical level at May Hill, southern Woolhope, and the southern Malverns. At the top of the Sedgley Limestone Dr. E. V. Tucker has found a band of *Shaleria ornatella* which probably indicates the presence of the Upper Leintwardine Beds. A similar band was collected some years ago from a temporary excavation at Gornal (SO 919932). The Whitcliffe Beds at Lye are 25 ft. thick and yield the characteristic fauna. The Ludlow Bone Bed is here split into several thin layers over a thickness of 1 ft. and is succeeded by the Downton Castle Sandstone. The highest Whitcliffe Beds, the Ludlow Bone Bed and the basal shaly siltstones of the Downtonian are also well seen in the old railway cutting at Netherton (SO 936874).

(ii) *Basin Facies*

This section also includes the southern marginal areas of Llandovery and Pembrokeshire. For the Welsh Borderland and central Welsh areas a generalized succession was introduced in a paper describing a Geologists' Association excursion to the Ludlow district (Allender and others, 1959). Further details are given by Holland (1962) who also summarizes the differences in lithology and thickness between basin and shelf facies and discusses the correlation within the basin facies. The correlation with the shelf facies was also dealt with by Lawson and others (1956).

At Builth (column 11) and Cwm Craig Ddu (column 12) the Lower Ludlow Graptolitic Shales have been shown to include the zone of *Monograptus vulgaris* (Wood, 1900) but in other areas the beds below the *M. nilssoni-M. scanicus* Zone were not studied. The rich shelly fauna of the *Chonetoidea grayi* Beds of Builth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raw 1953
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Llan-Wen Hill Beds
Dalmanella lunata Beds
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Wern Quarry Beds
Knucklas Castle Beds
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etoidea grayi Beds
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Middle and Upper Bailey Hill Beds
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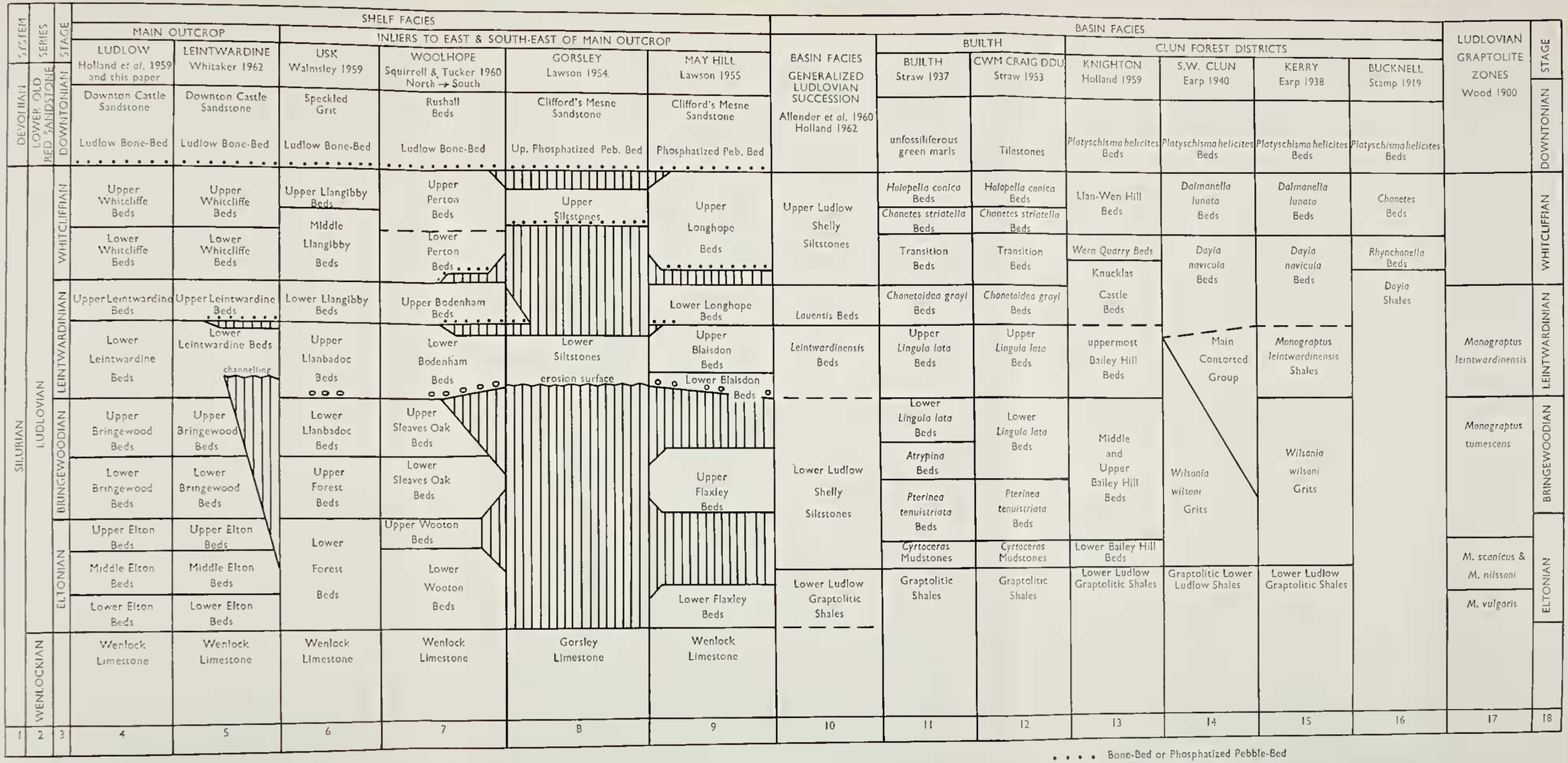
13
14
Bone-Bed or Phosphatiz
Conglomeratic bands
Erosion surface

TABLE II.—LUDLOVIAN CORRELATION IN THE WELSH BORDERLAND



provides a strong correlation link with the Upper Leintwardine Beds of Ludlow. The Clun Forest districts have been fully discussed by Holland (1959 : 470). Other areas for which revised successions have not yet been published are considered briefly below.

(1) *Brecon Anticlinal*

Kirk (1951) has so far published only a short summary of the succession in this extensive area. There is a general similarity to the Builth succession. The Striped Flags are the approximate equivalent of the Lower Ludlow Shelly Siltstones.

(2) *Bishop's Castle*

In the paper by Allender and others (1959) there is a brief survey of the Ludlovian rocks of this area. The succession is similar, especially in the upper part, to that at Knighton, but it is important to note that the *Neobeyrichia lauensis-Chonetoidea grayi* assemblage occurs in strata equivalent in position to the Lower Knucklas Castle Beds of Knighton which lack this distinctive fauna. Also there are interesting local variations and facies changes at the base of the Lower Ludlow Shelly Siltstones and in the various graptolitic shales and shelly siltstones which lie below.

(3) *Radnor Forest*

Unpublished work by S. H. Straw and, more recently, by R. J. Bailey has shown that in the Radnor Forest area the Lower Ludlow Shelly Siltstones change laterally from the Clun Forest development, with its turbidite beds of calcareous siltstone, to the *Cyrtoceras* Mudstone facies of the Builth district.

(4) *Towy Anticline*

The Ludlovian rocks of the south-eastern flank of the Towy Anticline have been recently studied by both Price (1957) and Potter (1960). They have been able to correlate the succession with the revised classification at Ludlow. An important feature of the area is the development south-westwards of shallow water and even terrestrial deposits (e.g. the red Trichrûg Beds) in the Bringewoodian.

(5) *Pembrokeshire*

In west Pembrokeshire, the Grey Sandstone Series was assigned by the Geological Survey (Cantrill *et al.*, 1916 : 58) to the Ludlovian. Its base is difficult to define, and the junction with the overlying Red Marls is not necessarily a constant horizon. Fossils are scarce, particularly in the uppermost 800 ft. for which there is no positive evidence so far of Ludlovian age. Until current work on the Sandstone Series faunas is completed, no basis for correlation with the Welsh Borderland Ludlovian exists, and the assumption that the change of colour from grey to red marks the top of the Ludlovian is not necessarily valid (Walmsley 1962).

VIII. LIST OF FOSSILS

Except where otherwise stated (under Bryozoans), this list includes only those fossils collected by the present writers.

Relative abundance is suggested by the following symbols :—

P = present
FC = fairly common
C = common

If it is considered that a particular fossil would be found at most of the exposures of a stratigraphical division with, say, half an hour's study, that fossil has been recorded as FC. A species recorded as P cannot be guaranteed to appear either at any given place or in any given time. A common fossil will normally be evident in the first five minutes, although it must be remembered that Ludlovian fossils tend to occur in bands.

	Wenlock Shales	Wenlock Limestone	Lower Elton Beds	Middle Elton Beds	Upper Elton Beds	Lower Bringewood Beds	Upper Bringewood Beds	Lower Leintwardine Beds	Upper Leintwardine Beds	Lower Whitcliffe Beds	Upper Whitcliffe Beds
Anthozoa											
Entelophyllum articulatum (Wahlenberg)		P									
Favosites asper d'Orbigny		P									
—— *gothlandicus* forma *forbesi* (Edwards & Haime)							FC				
Favosites spp.		FC									
Halysites catenularius (Linnaeus)			P				P				
Heliolites interstinctus (Linnaeus)		FC					FC				
Rhabdocyclus porpitoides (Lang & Smith)						P	P				
Thecia grayana Edwards & Haime		P									
solitary corals[1]	P	P	P			P	FC	P			
Stromatoporoidea											
Stromatopora carteri Nicholson		P									
—— sp.							P				
Bryozoans[2]											
Batostoma sp.						P	C	FC			
Batostomella hemiseptensis Owen						P					
Batostomella hexamesopora Owen	P					C	P	P			
Bythopora parallela Owen	P					FC	FC				

	Wenlock Shales	Wenlock Limestone	Lower Elton Beds	Middle Elton Beds	Upper Elton Beds	Lower Bringewood Beds	Upper Bringewood Beds	Lower Leintwardine Beds	Upper Leintwardine Beds	Lower Whitcliffe Beds	Upper Whitcliffe Beds
BRYOZOANS[2]—*contd.*											
Calamotrypa millichopensis Owen						FC	FC				
Dekayella megacanthopora Owen						P					
Dekayella ramosa Owen						P	P	P			
Dekayella whitcliffensis Owen											C
Eridotrypa umbonensis Owen						P					
Favositella interpuncta (Quenstedt)					P	P	P				
Fistulipora crassa Lonsdale						P					
Fistulipora strawi Owen			P		FC	C	C	C			
Fistulipora umbrosa Owen						P	FC				
Leioclema explanatum Bassler						P					
Leioclema ludlovensis Owen						C	C	P		P	P
Leptotrypella leintwardinensis Owen								P			
Monotrypa crenulata Nicholson						P					
Monotrypa flabellata Owen						P					
Monotrypa patera Owen						C	FC				
Nematopora hexagona Owen			FC		FC	C					
Orbignyella fibrosa (Lonsdale)								C		P	
Ptilodictya gracile Owen			P			FC	C				
Ptilodictya lanceolata (Goldfuss)						P					
Rhombopora minima Owen			FC		FC	C	C				
Rhombopora mesopora Owen									FC		
undetermined bryozoans	P	P									
BRACHIOPODA											
Atrypa reticularis (Linnaeus)		FC	FC	P		C	C	C	P-C[3]		
Brachyprion sp. nov.	P				P	FC	P				
Camarotoechia nucula (J. de C. Sowerby)		P		P	P	P	P	C	C	C	C
Chonetes lepisma (J. de C. Sowerby)					FC[4]	FC	P	FC	P		
—— *minimus* (J. de C. Sowerby)			P			P					
Chonetoidea grayi (Davidson)	P		FC	FC	P	P		P	FC[5]		
Conchidium knighti (J. Sowerby)							C				
Craniops [*Pholidops*] *implicata* (J. de C. Sowerby)						P	P	P	P		P
Cyrtia exporrecta (Wahlenberg)	P										
" *Dalmanella* " spp.						P	P		P		
Dayia navicula (J. de C. Sowerby)				P		P	P	C	FC	FC[6]	
Dicoelosia [*Bilobites*] *biloba* (Linnaeus)	P		P								
Dolerorthis rustica (J. de C. Sowerby)	P	P									
Eospirifer plicatellus (Linnaeus)			P								
—— *radiatus* (J. de C. Sowerby)		P		P			P				
Fardenia pecten (Linnaeus)[7]						P					

	Wenlock Shales	Wenlock Limestone	Lower Elton Beds	Middle Elton Beds	Upper Elton Beds	Lower Bringewood Beds	Upper Bringewood Beds	Lower Leintwardine Beds	Upper Leintwardine Beds	Lower Whitcliffe Beds	Upper Whitcliffe Beds
BRACHIOPODA—*contd.*											
Glassia sp.			P								
Gypidula galeata (Dalman)		P	P								
—— *lata* Alexander						C	FC				
Howellella [*Delthyris*] *elegans* (Muir-Wood)			P			P	P	P	P		P[8]
Isorthis [*Dalmanella*] *orbicularis* (J. de C. Sowerby)[9]						FC	FC	C	FC	P	
Leptaena rhomboidalis (Wilckens)		P	P	P		C	C	C	FC		
Leptostrophia filosa (J. de C. Sowerby)						FC	P	P			
Lingula lata J. de C. Sowerby				P	P			P[10]	P		
—— *lewisi* J. de C. Sowerby	P					P	P	P	P		P
—— spp.			P		P	P					
Orbiculoidea rugata (J. de C. Sowerby)								P	P	P	P
Plectatrypa imbricata (J. de C. Sowerby)			P								
Protochonetes ludloviensis Muir-Wood[11]						P		P	C	FC	C
Resserella [*Parmorthis*] cf. *elegantula* (Dalman)		P	FC								
Rhipidomella hybrida (J. de C. Sowerby)		P									
Salopina [*Dalmanella*] *lunata* (J. de C. Sowerby)[9]								P	FC	FC	C
Schizocrania striata (J. de C. Sowerby)									P		
Shaleria [*Brachyprion*] *ornatella* (Davidson)							P	C[12]	C		
—— sp. nov.						P					
Sowerbyella sp.		P									
Sphaerirhynchia [*Wilsonia*] *wilsoni* (J. Sowerby)		P				FC	FC	C[13]			
Strophonella euglypha (Hisinger)		P				FC	C	P			
—— *funiculata*(M'Coy)[14]						P	P				
Whitfieldella canalis (J. de C. Sowerby)								P			
LAMELLIBRANCHIA											
Cypricardinia planulata (Conrad)						P	P	P	P		
—— *subplanulata* (Reed)						P					
Fuchsella [*Orthonota*] *amygdalina* (J. de C. Sowerby)								P	P	C	FC
—— *retusa* (J. de C. Sowerby)										P	
Goniophora cymbaeformis (J. de C. Sowerby)								P		P	P
Grammysia sp.								P			

	Wenlock Shales	Wenlock Limestone	Lower Elton Beds	Middle Elton Beds	Upper Elton Beds	Lower Bringewood Beds	Upper Bringewood Beds	Lower Leintwardine Beds	Upper Leintwardine Beds	Lower Whitcliffe Beds	Upper Whitcliffe Beds
LAMELLIBRANCHIA—*contd.*											
Modiolopsis complanata (J. de C. Sowerby)											P
Nuculites spp.			P							P	P
Plethomytilus [*Mytilus*] *mytilimeris* (Conrad)						P			P		
Pterinea nupera Reed . . .								P	P		
—— spp.			P			P	P	P		P	P
Pteronitella retroflexa (Wahlenberg) .						P		P	P		FC
Slava [*Cardiola*] *interrupta* (Sowerby)			P	P	P			P	P		
Tolmaia [*Pterinea*] *sowerbyi* (McCoy)						P	P				
GASTROPODA											
Bellerophon sp.										P	
Bembexia [*Murchisonia*] *lloydi* (J. de C. Sowerby)								P	P	P	
Bucanopsis [*Bellerophon*] *expansus* (J. de C. Sowerby)									P	P	
Cyclonema [*Turbo*] *corallii* (J. de C. Sowerby)							P		P		
Hormotoma [*Murchisonia*] *articulata* (J. de C. Sowerby)									P		
Liospira [*Pleurotomaria*] *striatissima* (Salter)						P	P				
Loxonema [*Holopella*] sp.[15] . .						P		P	P		P
Murchisonia sp.						P	P				
Poleumita [*Horiostoma*] *globosa* (Schlotheim)						P	P				
—— [——] *discors* (J. de C. Sowerby)		P									
CEPHALOPODA											
Cyrtoceras sp.										P	
Dawsonoceras annulatum (J. Sowerby)	P										
Kionoceras angulatum (Wahlenberg) .			P	P			P	P	P	P	
Lituites ibex J. de C. Sowerby . .		P						P		P	P
Michelinoceras [*Orthoceras*] cf. *argus* (Barrande)				P							
—— [——] *bullatum* (J. de C. Sowerby)						P		P	P	P	P
—— [——] cf. *gregarium* (J. de C. Sowerby)					P						
—— [——] *ibex* (J. de C. Sowerby) .										P	
—— [——] *imbricatum* (Wahlenberg)									P	FC	P

	Wenlock Shales	Wenlock Limestone	Lower Elton Beds	Middle Elton Beds	Upper Elton Beds	Lower Bringewood Beds	Upper Bringewood Beds	Lower Leintwardine Beds	Upper Leintwardine Beds	Lower Whitcliffe Beds	Upper Whitcliffe Beds
CEPHALOPODA—*contd.*											
Michelinoceras [*Orthoceras*] *subundulatum* (Portlock)	P			P	P						
—— [——] *tenuiannulatum* (McCoy)						P					
unidentified orthocones	P	P	P	C	FC		P		P	P	
ANNELIDA											
Cornulites serpularius Schlotheim						P					P
Keilorites [*Trachyderma*] sp.									P	P	
Serpulites longissimus J. de C. Sowerby[16]								P	P	FC	FC
Spirorbis sp.					P	P					
Tentaculites ornatus						P					
—— *tenuis* (J. de C. Sowerby)									P	P	
TRILOBITA											
Acastella cf. *spinosa* (Salter)											P
Calymene neointermedia (R. & E. Richter)									FC[17]		
—— spp.	P	P	P				P	P	P	P	
Dalmanites caudatus (Brünnich)	P										
—— *myops* (König)[18]	P	P	P	P	P	P	P				
Encrinurus spp.[19]						P	P		FC[20]		
Hemiarges sp.						P					
Homalonotus knighti König										P	
Phacops sp.	P										
Proetid		P	P					P	P		
OSTRACODA											
Beyrichia kloedeni McCoy var. *antiquata* Jones								P			
—— —— McCoy var. *torosa* Jones								P	P	P	FC
—— spp.		P			P	P		P			P
Bythocyprids						P			P	P	
Hemsiella [*Beyrichia*] *maccoyana* (Jones)[21]	FC	P	P	FC		P		P			
Neobeyrichia lauensis (Kiesow)[21]									FC[22]		
Primitia sp.		P				P					
EURYPTERIDA[23]											
Eurypterid fragments										P	
CRINOIDEA											
crinoid columnals	P	C	P	P		P	C	FC[24]	P	P	P

	Wenlock Shales	Wenlock Limestone	Lower Elton Beds	Middle Elton Beds	Upper Elton Beds	Lower Bringewood Beds	Upper Bringewood Beds	Lower Leintwardine Beds	Upper Leintwardine Beds	Lower Whitcliffe Beds	Upper Whitcliffe Beds
GRAPTOLOIDEA											
Gothograptus nassa (Holm)	P										
Monograptus chimaera (Barrande)					P						
—— *colonus* (Barrande)				FC							
—— *comis* Wood				P							
—— *dubius* (Suess)	P			P							
—— *leintwardinensis* Lapworth								FC	P		
—— *leintwardinensis* Lapworth var. *incipiens* Wood							P				
—— *nilssoni* (Barrande)				P							
—— *scanicus* (Tullberg)				P							
—— *tumescens* Wood			P[25]	C	P						
—— *uncinatus* (Tullberg) var. *orbalus* Wood				P							
—— *varians* Wood				P							
—— *vulgaris* Wood	P										
OF UNCERTAIN AFFINITY											
Hyolithes [*Theca*] *forbesi* (Sharpe)										P	

NOTES

1. These are small trochoid corals, many of which resemble *Phaulactis*.
2. Dr. D. E. Owen has kindly supplied the list of Ludlovian Bryozoans from the Ludlow District. Details of his work are contained in Owen (1962).
3. Commoner in the east of the area.
4. Fairly common locally.
5. Fairly common in bands.
6. Fairly common in the basal beds.
7. According to Boucot (1959) the genus *Fardenia* is restricted to the upper Ordovician and Lower Llandovery. The species *Fardenia pecten* (Linnaeus) is assigned to the new genus *Chilidiopsis* Boucot.
8. Very common in bands in the topmost beds.
9. Professor Boucot (1960) assigns the familiar Ludlovian species *Dalmanella orbicularis* (J. de C. Sowerby) to the genus *Isorthis* Kozlowski and erects the new genus *Salopina* for the species *Dalmanella* [*Orthis*] *lunata* (J. de C. Sowerby).
10. Commoner in the west of the area.
11. See Muir-Wood (1962).
12. Commoner in the east of the area, particularly in the higher beds.
13. Less common in the west of the area.
14. A more correct designation is probably *Amphistrophia funiculata*. See Williams (1953 : Plate 12).
15. According to Knight & others (1960 : I311) *Holopella* M'Coy is a synonym of *Loxonema* Phillips.
16. According to Howell (1962 : W163) *Serpulites longissimus* J. de C. Sowerby is the type species of the genus *Campylites* Eichwald, 1856.
17. Fairly common in bands.
18. See Dean (1960).

19. According to Tripp (1962) the *Encrinurus punctatus* group is represented in Britain by *E. tuberculatus* (Buckland) in the Wenlockian and *E. stubblefieldi* Tripp in the Ludlovian.
20. Fairly common in bands.
21. See Martinsson (1962).
22. Fairly common in bands, especially in the west.
23. According to Kjellesvig-Waering (1961) four species are present in the " Upper Ludlow " of the Ludlow District. Three of these are from the Whitcliffe at Ludlow but no more precise stratigraphical information is available. None is recorded from lower in the Silurian succession of the district but many Downtonian forms (here included within the Silurian) are described.
24. Fairly common in the basal beds ; mostly round but some pentagonal.
25. Present in the topmost beds only.

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APPENDIX 1 : LIST OF LOCALITIES

In the following list numbers 1 to 77 refer to localities given in the detailed descriptions of important areas (Section IV) and their positions are shown in Text-fig. 7 (Whitcliffe : localities 1–13), Text-fig. 8 (Wigmore Road : localities 14–28), Text-fig. 9 (Mary Knoll Valley : localities 29–37) and Text-fig. 10 (Downton Gorge and Burrington : localities 38–77). The remainder of the list is arranged according to National Grid squares, starting in the south-west. Standard localities (Sections III and VI) and selected localities for the stratigraphical divisions (Section III) (where not included under localities 1–77) are to be found in this part of the list. They are indicated throughout the complete list by the letters " S " (standard locality) and " R " (selected locality representative of a stratigraphical division) in the final column. The National Grid letters in all cases are SO. Abbreviations for the stratigraphical divisions exposed at the localities are as listed on p. 103. In most cases the location of each exposure is also given as an approximate bearing and distance from a point indicated by name on the 1 : 25000 Ordnance Survey sheets SO47 and SO57.

Locality number	Grid reference	Stratigraphical divisions exposed	Location	" S " and " R " localities
Whitcliffe				
1	50747428	L.L.B.	small exposure below path 180 yds S.S.E. Dinham Bridge	
2	50717429	L.L.B.	exposure behind seat 160 yds S.S.E. Dinham Bridge	
3	50717428	L.W.B. U.L.B. L.L.B.	cliff 180 yds S.S.E. Dinham Bridge (standard sections for both L.L.B./U.L.B. and U.L.B./L.W.B. boundaries)	S
4	50827421	U.L.B.	pathside exposure 290 yds S.E. Dinham Bridge	
5	50907417	L.W.B.	pathside exposure 380 yds W. Ludford Bridge	
6	50967414	U.W.B. L.W.B.	Whitcliffe quarry 345 yds W.S.W. Ludford Bridge	S
7	51237413	D.C.S. B.B. U.W.B.	exposure at junction of " Ludford Lane " and Leominster road 80 yds S.S.W. Ludford Bridge	S
8	50717425	L.W.B.	path exposure 210 yds S. Dinham Bridge	R
9	50657433	L.W.B.	pathside exposure 120 yds S.S.W. Dinham Bridge	
10	50657434	U.L.B.	small pathside exposure 110 yds S.S.W. Dinham Bridge	
11	50627440	U.L.B. L.L.B.	path section 70 yds S.W. Dinham Bridge	R
12	50627442	L.W.B.	exposures 70 yds W.S.W. Dinham Bridge	
13	50627445	L.W.B.	small quarry 70 yds W. Dinham Bridge	

Locality number	Grid reference	Stratigraphical divisions exposed	Location	"S" and "R" localities
Wigmore Road				
14	47167301	W.L.	roadside quarry 460 yds E.S.E. Monstay	R
15	47227304	W.L.	roadside quarry 520 yds E.S.E. Monstay	
16	47267301	L.E.B. W.L.	quarry in coppice 600 yds E.S.E. Monstay	SR
17	47777324	M.E.B.	stream exposure 450 yds S.S.W. Gorsty	R
18	47897357	U.E.B.	roadside exposure 70 yds S.S.W. Gorsty	R
19	48287377	L.B.B.	roadside exposure 170 yds N.N.E. Mary Knoll House	R
20	48557369	U.B.B.	trackside quarry 400 yds E. Mary Knoll House	R
21	48577360	—	viewpoint at summit of Mary Knoll	
22	47327382	U.B.B.	landslip exposure 700 yds W.N.W. Gorsty	R
23	48747389	U.B.B.	roadside exposure 660 yds E.N.E. Mary Knoll House	R
24	48887392	L.L.B.	roadside quarry 810 yds E.N.E. Mary Knoll House	R
25	49107399	L.L.B.	roadside quarry 1080 yds E.N.E. Mary Knoll House	R
26	49227407	U.L.B.	roadside exposure 1230 yds E.N.E. Mary Knoll House	R
27	49307412	U.L.B.	roadside exposure 840 yds W. Whitcliffe North	R
28	49797430	L.W.B.	roadside exposure 330 yds N.W. Whitcliffe North	R
Mary Knoll Valley				
29	49737244	L.W.B.	large quarry 270 yds E.S.E. Sunnyhill Cottages	R
30	49537255	L.L.B. U.B.B.	large quarry near Sunnyhill Cottages (Sunnyhill Quarry)	S
31	49437255	U.B.B.	small quarry 100 yds N.W. Sunnyhill Cottages	
32	49367260	L.B.B.	track exposure 180 yds N.W. Sunnyhill Cottages	
33	49347263	L.B.B.	roadside section 240 yds N.W. Sunnyhill Cottages	R
34	49307268	L.B.B.	roadside section 290 yds N.W. Sunnyhill Cottages	
35	49337268	U.B.B.	small quarry 270 yds N.W. Sunnyhill Cottages	R
36	49437270	L.L.B.	crags 210 yds N.N.W. Sunnyhill Cottages	
37	49427242	U.L.B.	exposure in overgrown track 130 yds S.S.W. Sunnyhill Cottages	
Downton Gorge				
38	43657220	W.S.	exposures in wooded bank 180 yds N.N.E. Burrington Bridge	R
39	43507228	W.S.	exposures in wooded bank 280 yds N.N.W. Burrington Bridge	
40	43347227	W.S.	trackside exposure 370 yds N.W. Burrington Bridge	R
41	43277232	W.L.	small exposure above wooded bank 470 yds N.W. Burrington Bridge	
42	43237273	M.E.B.	exposure above path 90 yds N.N.W. Owney Cottage	
43	43037280	U.E.B.	exposures in steep wooded slope 380 yds S. Bow Bridge	R
44	42897296	L.B.B.	small quarry 60 yds N. of eastern end Downton Bridge	R
45	43067313	U.B.B.	riverside exposures just S. Bow Bridge	R
46	43117320	L.L.B.	small exposure below tree 100 yds N.E. Bow Bridge	
47	43197316	U.L.B.	very small trackside exposures 150 yds E.N.E. Bow Bridge	

Locality number	Grid reference	Stratigraphical divisions exposed	Location	"S" and "R" localities
48	43297312	U.L.B.	quarry 260 yds E. Bow Bridge	
49	43457352	L.W.B.	quarry at western side Hay Mill	R
50	43777358	L.W.B.	riverside exposures E. Hay Mill	R
51	43987400	L.W.B.	river cliff 630 yds S.W. Castle Bridge	
52	44027390	U.W.B.	quarried crags above river 670 yds S.W. Castle Bridge	R
53	44107367	U.W.B. L.W.B.	quarries 820 yds S.S.W. Castle Bridge	R
54	44167411	U.W.B.	exposures above riverside path 400 yds S.W. Castle Bridge	R
55	44277415	U.W.B.	exposures above riverside path 260 yds S.W. Castle Bridge	
56	44427425	U.W.B.	pathside section 70 yds S.W. Castle Bridge	R
57	44497427	D.C.S. B.B.	trackside quarry near S. end Castle Bridge	R
58	44427402	D.C.S. U.W.B.	track section 320 yds S.S.W. Castle Bridge	
59	44497409	T.S. D.C.S.	track section 230 yds S. Castle Bridge	
Burrington				
60	44387242	W.S.	laneside section 400 yds N.N.E. Burrington Church	
61	44337250	W.S.	laneside section 460 yds N.N.E. Burrington Church	R
62	44257253	W.L. W.S.	lane section 490 yds N. Burrington Church	
63	44257255	W.L.	quarry E. of lane 510 yds N. Burrington Church	R
64	44177257	W.L.	lane section 540 yds N.N.W. Burrington Church	
65	44377266	W.L.	quarry south of lane 650 yds N.N.E. Burrington Church	R
66	44507277	L.E.B.	small laneside exposure 800 yds N.N.E. Burrington Church	
67	44537278	L.E.B.	small stream exposure N. of lane 840 yds N.N.E. Burrington Church	
68	44147263	W.L.	track section 620 yds N.N.W. Burrington Church	
69	43897278	M.E.B. L.E.B.	stream section 710 yds E.N.E. Owney Cottage	SR
70	43667266	L.E.B.	stream section 450 yds E. Owney Cottage	R
71	43617265	L.E.B.	stream section 380 yds E. Owney Cottage	
72	43527264	M.E.B.	stream section 290 yds E. Owney Cottage	R
73	43487262	L.E.B.	stream section 250 yds E.S.E. Owney Cottage	R
74	43387264	M.E.B.	stream section 170 yds E. Owney Cottage	
75	43377263	M.E.B.	stream section 120 yds E.S.E. Owney Cottage	R
76	43677283	U.E.B. M.E.B.	trackside section 920 yds E. Downton Bridge	S
77	43757307	L.L.B. U.B.B.	scarp top quarry 790 yds E. Bow Bridge	R

Locality number	Grid reference	Stratigraphical divisions exposed	Location	"S" and "R" localities
Other localities arranged under Kilometre Grid Squares				
Grid Square 43/71				
78	43057142	W.S.	small exposure in wooded bank 180 yds W. The Willows	
79	43237172	W.S.	small riverside exposures 550 yds S.W. Burrington Bridge	
80	43457187	W.S.	riverside exposure 270 yds S.W. Burrington Bridge	
Grid Square 43/72				
81	43097283	L.B.B.	uppermost exposures on wooded slope 350 yds S.S.E. Bow Bridge	
82	43257264	M.E.B.	stream exposure 20 yds S.W. Owney Cottage	
83	43337294	U.B.B.	small exposures 390 yds S.E. Bow Bridge	
84	43957261	W.L.	trackside exposures 660 yds N.N.W. Burrington Church	
Grid Square 43/73				
85	43417322	L.W.B.	exposure 410 yds E.N.E. Bow Bridge	
86	43437331	L.W.B.	quarry 260 yds S.S.W. Hay Mill	
87	43567333	L.W.B.	quarry 240 yds S.S.E. Hay Mill	
88	43677340	L.W.B.	track section 260 yds S.E. Hay Mill	
89	43957358	L.W.B.	quarry 530 yds E. Hay Mill	
Grid Square 44/71				
90	44147198	W.S.	roadside exposures 160 yds S.E. Burrington Church	
91	44247190	W.S.	exposures in sides of sunken lanes 230 yds S. Burrington Church	
92	44877180	W.S.	small exposures on Bowburnet Hill 790 yds E.S.E. Burrington Church	
Grid Square 44/72				
93	44227275	W.L.	stream section 740 yds N. Burrington Church	
94	44427286	M.E.B.	stream section 970 yds W.S.W. New House	
95	44517285	M.E.B.	small ditch exposure 880 yds W.S.W. New House	
96	44557287	M.E.B.	small stream exposure 830 yds W.S.W. New House	
97	44577288	M.E.B.	stream section 800 yds W.S.W. New House	
98	44627285	L.E.B.	stream section 750 yds W.S.W. New House	
99	44667239	W.S.	small exposure 590 yds N.E. Burrington Church	
100	44787240	W.S.	track sections 700 yds N.E. Burrington Church	R
101	44787280	L.E.B.	laneside (stream) section 600 yds W.S.W. New House	R
102	44917281	W.L.	trackside exposure 450 yds W.S.W. New House	
103	44937247	W.L.	track section 700 yds S.S.W. New House	
Grid Square 44/73				
104	44067308	L.B.B.	small exposure 830 yds S.E. Hay Mill	
105	44127323	L.L.B. U.B.B.	scarp top quarry 790 yds E.S.E. Hay Mill	

Locality number	Grid reference	Stratigraphical divisions exposed	Location	"S" and "R" localities
106	44187358	L.W.B.	quarry 870 yds S.S.W. Castle Bridge	
107	44427307	U.E.B.	small exposure 970 yds W.N.W. New House	R
108	44977388	U.W.B.	head of small stream 730 yds S.E. Castle Bridge	
Grid Square 45/72				
109	45017285	W.L.	track section 330 yds W.S.W. New House	
110	45127276	W.L.	stream section 300 yds S.W. New House	
111	45127288	W.L.	trackside exposures 200 yds S.W. New House	
112	45297273	W.L.	stream section 280 yds S. New House	
113	45377275	W.L.	stream section 280 yds S.S.E. New House	
114	45587238	W.S.	track section 760 yds S.S.E. New House	R
115	45647207	W.S.	stream exposures 610 yds W.N.W. Aston Church	
116	45827253	W.L.	trackside exposures 800 yds S.E. New House	
117	45877281	W.L.	stream exposure 690 yds E.S.E. New House	
118	45957263	W.L.	trackside section at west end Monstay Rough	
Grid Square 45/73				
119	45267302	M.E.B.	small exposure just W. New House	
120	45377358	U.L.B.	trackside exposure 680 yds N.N.E. New House	
121	45407369	U.L.B.	small quarry above track 810 yds N.N.E. New House	R
122	45417353	L.L.B.	trackside exposure 1070 yds S.W. Deepwood	
123	45467353	L.L.B.	trackside exposure 660 yds N.N.E. New House	
124	45467385	U.W.B. L.W.B.	stream section 800 yds S.W. Deepwood	
125	45507368	U.L.B.	trackside exposure 840 yds N.N.E. New House	R
126	45657348	L.L.B.	trackside exposure 1000 yds S.S.W. Deepwood	
127	45807353	U.B.B.	joint surfaces exposed by landslip 870 yds S.S.W. Deepwood	R
128	45827344	U.B.B.	trackside exposure 950 yds S.S.W. Deepwood	
129	45877375	L.W.B. U.L.B. L.L.B.	trackside section 630 yds S.S.W. Deepwood	R
130	45907363	L.L.B.	trackside exposure 740 yds S.S.W. Deepwood	
131	45957352	U.B.B. L.B.B.	stream section 850 yds S. Deepwood	S
132	45957376	L.L.B.	small excavation west of track 590 yds S.S.W. Deepwood	
133	45977370	L.L.B.	trackside exposure 650 yds S.S.W. Deepwood	
134	45977380	L.L.B.	quarry 540 yds S.S.W. Deepwood	
Grid Square 45/74				
135	45527405	D.C.S.	trackside exposure 600 yds W.S.W. Deepwood	
136	45577403	Downton Bone Bed	trackside exposure 600 yds W.S.W. Deepwood	
137	45757406	B.B. U.W.B.	small quarry south of track 400 yds S.W. Deepwood	R

Locality number	Grid reference	Stratigraphical divisions exposed	Location	"S" and "R" localities
138	45877400	W.B.	quarry near track 350 yds S.S.W. Deepwood	
139	45997407	T.S. D.C.S. (fault) U.W.B.	stream section north of track 230 yds S. Deepwood	
Grid Square 46/71				
140	46977196	W.L.	small quarry 280 yds E. Juniper Cottage	R
Grid Square 46/72				
141	46257216	W.S.	stream section 400 yds N.N.E. Aston Church	R
142	46537204	W.S.	stream exposure 500 yds E.N.E. Aston Church	
143	46837280	W.L.	small quarry (hen-run) on N. side Wigmore Road	
Grid Square 46/73				
144	46027368	U.B.B.	trackside exposures 660 yds S. Deepwood	
145	46027377	L.L.B.	exposure 570 yds S. Deepwood	
146	46027387	U.L.B.	trackside exposure 460 yds S. Deepwood	
147	46037391	L.W.B.	trackside exposure 410 yds S. Deepwood	
148	46117319	U.E.B.	trackside exposure 730 yds W. Monstay	
149	46117361	L.B.B.	exposure 740 yds S. Deepwood	
150	46177354	L.B.B.	exposure 830 yds S.S.E. Deepwood	
151	46197363	L.L.B.	exposure 740 yds S.S.E. Deepwood	
152	46217357	U.B.B.	exposure 800 yds S.S.E. Deepwood	
153	46327327	U.E.B.	trackside exposure 520 yds W.N.W. Monstay	
154	46417398	L.L.B.	exposure 540 yds S.E. Deepwood	
155	46737393	W.B.	trackside exposure 850 yds S.E. Deepwood	
156	46967373	U.B.B.	trackside exposure 1050 yds W.N.W. Gorsty	
157	46987328	M.E.B.	trackside exposure 1100 yds W.S.W. Gorsty	
158	46997336	U.E.B.	trackside exposure 1070 yds W.S.W. Gorsty	
Grid Square 46/74				
159	46137425	R.D. T.S.	stream section 100 yds E. Deepwood	
Grid Square 47/71				
160	47207189	W.L.	trackside exposure 500 yds E.S.E. Juniper Cottage	
161	47257187	W.L.	trackside exposure 600 yds E.S.E. Juniper Cottage	
162	47267184	L.E.B. W.L.	trackside exposure 600 yds E.S.E. Juniper Cottage	R
163	47267190	W.L.	trackside exposure 600 yds E.S.E. Juniper Cottage	R
164	47587158	U.E.B.	trackside exposure 950 yds S.S.W. High Vinnals	R
165	47607165	U.E.B.	small quarry 870 yds S.S.W. High Vinnals	R
166	47657170	U.E.B.	small quarry 800 yds S.S.W. High Vinnals	
Grid Square 47/72				
167	47027297	W.L.	trackside exposure 180 yds N.N.E. Juniper Cottage	
168	47127292	W.L.	quarry in wood at Pitch Coppice	

Locality number	Grid reference	Stratigraphical divisions exposed	Location	"S" and "R" localities
169	47207277	W.L.	small trackside quarry just S. Pitch Coppice	
170	47827283	U.E.B.	small trackside quarry 490 yds N. High Vinnals	R
Grid Square 47/73				
171	47077386	U.B.B.	exposure 970 yds W.N.W. Gorsty	
172	47157339	U.E.B.	trackside exposure 880 yds W.S.W. Gorsty	
173	47327343	U.E.B.	trackside exposure 700 yds W.S.W. Gorsty	
174	47337353	L.B.B.	trackside exposure 660 yds W.S.W. Gorsty	
175	47337364	L.B.B.	trackside exposure 640 yds W. Gorsty	
176	47627361	L.B.B.	trackside 330 yds W. Gorsty	
177	47687321	M.E.B.	stream exposure 530 yds S.S.W. Gorsty	
178	47727347	U.E.B.	roadside exposure 280 yds S.W. Gorsty	
179	47727361	L.B.B.	trackside exposure 220 yds W. Gorsty	
180	47797379	L.B.B.	trackside exposure 450 yds W.N.W. Mary Knoll House	
181	47807352	U.E.B.	roadside exposure 180 yds S.W. Gorsty	
182	47817328	M.E.B.	stream exposure 410 yds S.S.W. Gorsty	
183	47857332	M.E.B.	stream exposure 350 yds S. Gorsty	
184	47857354	U.E.B.	roadside exposure 120 yds S.W. Gorsty	
185	47857355	U.E.B.	trackside exposure 100 yds S.W. Gorsty	
Grid Square 47/74				
186	47047401	W.B.	exposure 1050 yds N.W. Gorsty	
187	47227436	T.S.	stream exposure 1100 yds N.W. Gorsty	
188	47237428	U.W.B.	trackside exposure 970 yds N.W. Gorsty	
189	47487420	U.W.B.	trackside exposure 790 yds N.N.W. Gorsty	
190	47807401	L.B.B.	trackside exposure 590 yds N.W. Mary Knoll House	
191	47927422	U.W.B.	roadside exposure 700 yds N.N.W. Mary Knoll House	
Grid Square 48/71				
192	48577149	L.L.B.	track section 860 yds N.W. Batchcott	
193	48587139	L.L.B.	track section 800 yds W.N.W. Batchcott	
194	48677131	L.L.B.	track section 700 yds W.N.W. Batchcott	
195	48807127	L.W.B.	track section 500 yds N.W. Batchcott	
Grid Square 48/72				
196	48737292	L.B.B. U.E.B.	track section 950 yds N.W. Sunnyhill Cottages	S
197	48887237	L.L.B.	track section 700 yds W.S.W. Sunnyhill Cottages	
Grid Square 48/73				
198	48187338	M.E.B.	stream exposure 300 yds S. Mary Knoll House	
199	48217399	L.B.B.	trackside exposure 400 yds N. Mary Knoll House	
200	48287354	U.E.B.	trackside exposure 150 yds S.S.E. Mary Knoll House	
201	48387378	L.B.B.	roadside exposure 250 yds N.E. Mary Knoll House	
202	48397368	L.B.B.	trackside exposure 230 yds E. Mary Knoll House	
203	48417361	L.B.B.	trackside exposure 240 yds E.S.E. Mary Knoll House	